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RADIO and ELECTRONICS

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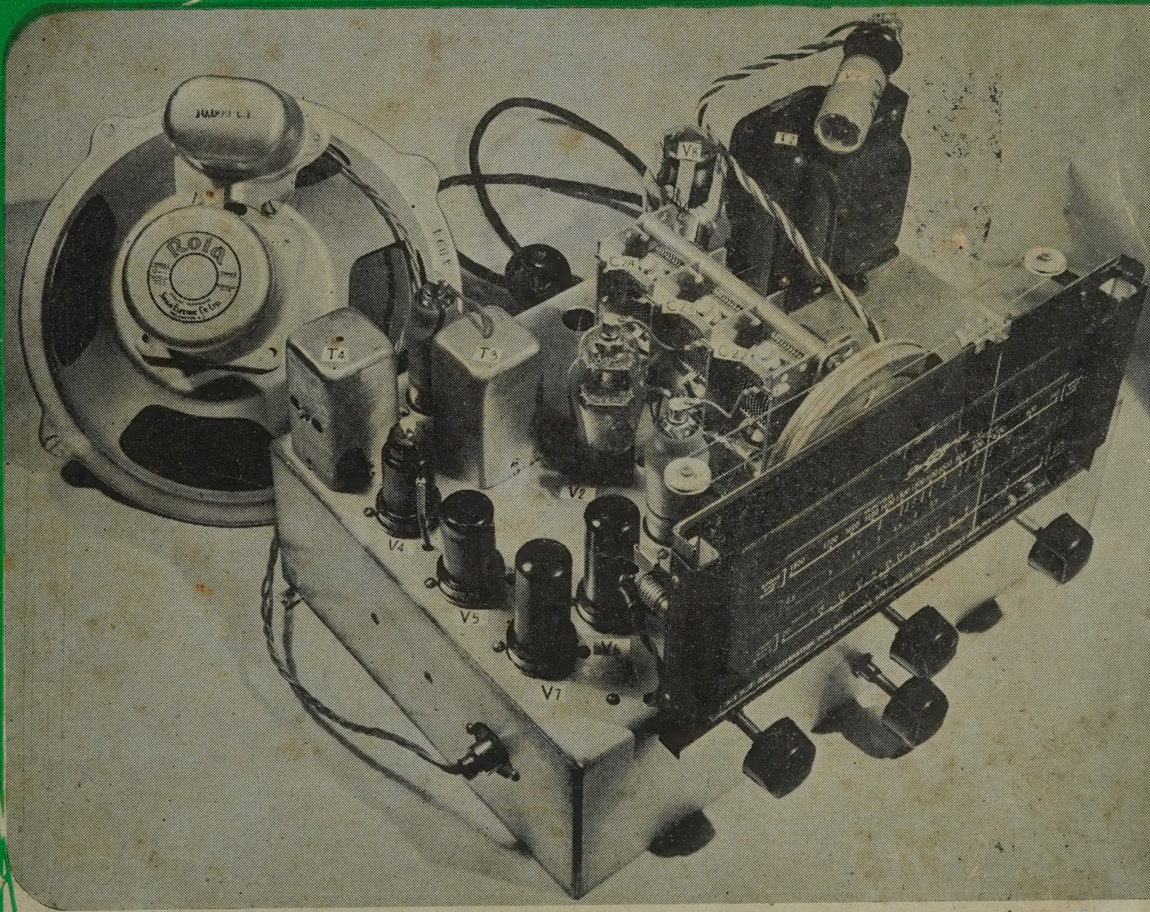

ELECTRONICS IN METEOROLOGY

THE PANORAMIC RECEIVER

RECEIVER BIAS SUPPLIES

SOME POINTS ABOUT SOLDERING

CALCULATION OF TRIODE CHARACTERISTICS OF PENTODES

OCTOBER 1, 1947

1/10

RADIO and ELECTRONICS

Vol. 2, No. 7 October 1st, 1947

Contents Page

OUR COVER

THIS MONTH'S photograph shows the "Radel All-Wave Eight," a description of which is to appear in the next issue of "Radio and Electronics." It employs an EF39 R.F. stage, 6F8-G oscillator and infinite impedance mixer, EF39 I.F. stage, 6B8 or 6B8-G second detector, A.V.C. and first audio, 6SJ7 triode connected phase inverter, push-pull 6V6's output stage, EM4 tuning indicator and 80 rectifier, making eight tubes exclusive of the magic eye.

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THE MAINTENANCE OF ELECTRONIC EQUIPMENT

Among members of both the electrical and electronic industries there seems to be general agreement that within a few years Australasia will see an enormous increase in the volume of electronic equipment employed in industrial applications. This granted, a very important question arises: who is to be responsible for maintaining this equipment?

On the 11th August of this year the Hutt Valley branch of the New Zealand Electricians' Institute Inc. showed a most laudably progressive spirit in selecting this question as the subject of a round-table discussion between a group of men broadly representative of the interests involved. From the discussion several salient points emerged. In the first place, there was general agreement that neither the present-day electrician nor the radio servicemen of to-day was suitably equipped to undertake servicing work on industrial-electronic equipment, which is sometimes exceedingly complex and sometimes well beyond the ken of either type of worker. At the same time there was a pronounced tendency among the electrical fraternity to under-estimate the standard of theory and practice to be required of an electronics maintenance engineer. Over a long period, it was argued, electricians had seen many innovations in their own field, and had so far succeeded admirably in keeping abreast of developments. Certain devices, notably high power mercury-arc rectifiers, had already been incorporated in the electrical engineer's repertoire, and there seemed no good reason why the term "electronics" should scare off the progressive electrician.

In spite of this attitude on the part of some of those representing the electrical industry, the general conclusion reached was that although the average radio serviceman could not be regarded as of high enough calibre, he would possess a slight advantage over the electrician, owing to the fact that his every-day work is with vacuum tubes, while that of the electrician is not.

An apparently minor, but in reality a very important feature of the discussion was the tendency among speakers to confuse the educational requirements of the maintenance man with those of the design engineer.

It appeared in this way that most of those actively concerned in the discussion realized the extreme importance of better basic training for a career in individual electronics than is provided at present either for electrical wiremen on the one hand or for radio servicemen on the other. The spontaneous manner in which this point was debated towards the end of the evening demonstrated the excellently non-partisan attitude of the majority of those present, and augured well for the future as long as the subject is not allowed to drop.

Such matters as whether in the future an entirely separately trained individual will be required, or whether electricians or radio servicemen (each with a modicum of training in the other's field) will be able to cope with electronic maintenance were also touched upon, and revealed a great variety of individual opinions—so great, in fact, that no definite conclusions were reached.

This necessarily sketchy description of a very interesting and constructive evening's discussion has been given here with a purpose—in order to precipitate some thought for the future among the radio industry. Nothing is surer than that electronics will come into its own in this country, even if in a somewhat belated manner. Likewise, nothing will be more calculated to hold back its individual application than a lack of trained personnel for its maintenance. Now is the time to act if men are to be ready when the time comes to service large quantities of expensive equipment. Admittedly, the situation bristles with difficulties, but none of them are incapable of solution if all concerned exhibit the same live spirit as did the Hutt Valley branch of the N.Z.E.I. in arranging the meeting we have reported above.

ELECTRONICS IN METEOROLOGY

THE THIRD OF A SERIES OF ARTICLES DESCRIBING ELECTRONIC DEVICES THAT ASSIST THE MODERN METEOROLOGIST

By R. E. EWING, B.Sc.

THE VARIABLE RADIO-FREQUENCY RADIOSONDE

In the description of radiosondes given in the last article, it was shown that these consist essentially of two main parts—the meteorologically sensitive elements and the radio transmitter unit. Further, it was shown that either one of two principles could be employed in the conversion of the meteorological measurements into radio signals, namely, the chronometric principle or the variable frequency Using the latter principle are the audio-modulated types of radiosonde which were described in the last article, and also the variable radio frequency types, some examples of which will now be described.

VAISALA RADIOSONDE

The Vaisala radiosonde was one of the earlier radiosondes being developed by Dr. Vilho Vaisala, of Finland, about 1935. It was perhaps the first of the modern radiosondes, and certain features of its design are incorporated in several other radiosondes in use to-day.

In this radiosonde the meteorological element varies the capacity of a condenser attached to the element in a similar manner to the way the meteorological element of the Kew radiosonde varies the inductance of an iron-cored winding. The elements themselves consist of an aneroid capsule for pressure, bimetallic strip for temperature, and hair hygrometer for humidity, and each element condenser is switched in turn into the tank circuit of a simple radio transmitter by means of a windmill driven switch which rotates in the wind stream caused by the ascending radiosonde.

In the design of any radiosonde one of the chief problems is not necessarily how to convert the meteorological variations into corresponding variations in the radio signals, but rather how to prevent other factors from causing unwanted variations in the radio signals.

In the Vaisala radiosonde this difficulty is overcome in an ingenious manner by the use of the two fixed condensers which, in addition to the three meteorological element condensers, are switched into the transmitter tank circuit. The capacities of the fixed condensers are so chosen that one is slightly less and the other slightly larger than any value of the variable meteorological element condensers. In this way the frequency interval between the fixed condensers serves as a unit in which the other frequency variations are measured, and so any frequency drift merely displaces the position of this unit, but does not alter its dimensions. The theory of this process can be demonstrated as follows:—

Let—

λ = the wavelength sent with a given meteorological condenser.

λ_1 = the wavelength sent with the larger fixed condenser.

λ_2 = the wavelength sent with the smaller fixed condenser.

C, C_1, C_2 = the capacities of the condensers.

C_0 = the plate to cathode capacity of the valve.

L = the inductance of the tank circuit.

Then

$$\lambda^2 = 4\pi^2 L(C + C_0)$$
$$\lambda_1^2 = 4\pi^2 L(C_1 + C_0)$$
$$\lambda_2^2 = 4\pi^2 L(C_2 + C_0)$$

Eliminating L and C_0 we obtain a relation

$$\frac{\lambda_1^2 - \lambda^2}{\lambda_1^2 - \lambda_2^2} = \frac{C_1 - C}{C_1 - C_2} = \lambda$$

Now since C_1 and C_2 are constant and C is a function of one of the meteorological elements y is a function of **this element only.**

Further, if the plates of the tuning condenser in the receiver are semicircular λ^2 is linear with respect to its scale reading n

$$\text{and so } \lambda = \frac{n_1 - n}{n_1 - n_2}$$

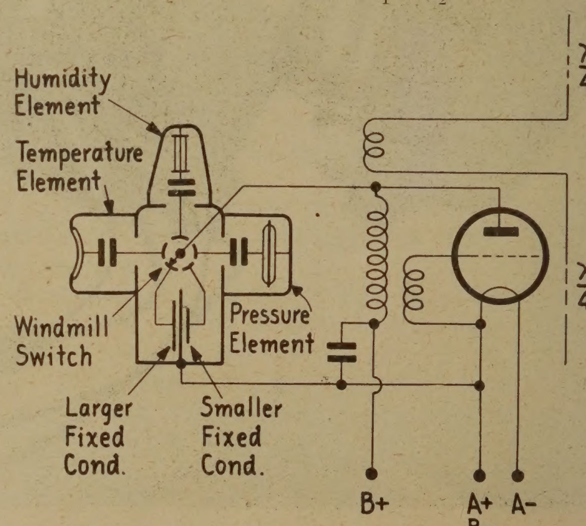

Fig. 1. Circuit diagram of the Vaisala radiosonde.

Thus the correction for frequency drift is valid and the value of the meteorological element can be obtained accurately from the readings, on the receiver tuning condenser, of the signals sent by the meteorological elements and the two fixed condensers.

Another advantage of this method of allowing for frequency drift is that the simplest type of radio transmitter can be employed thus enabling the weight of the radiosonde to be kept down. Indeed the Vaisala radiosonde complete with battery weighs only 12 ounces, which is considerably less than that of either of the two modulated audio frequency radiosondes previously described, namely, the British Kew (2 lb. 12 ozs.), and the American Diamond Hinman (2 lb. 14 ozs.).

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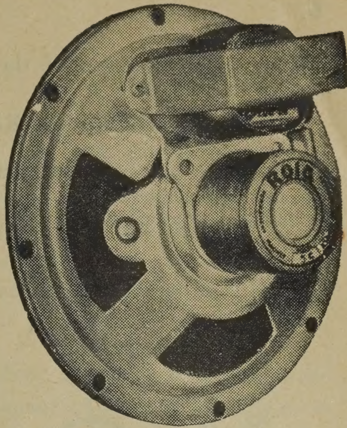

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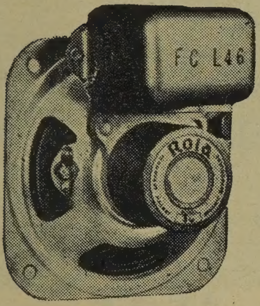

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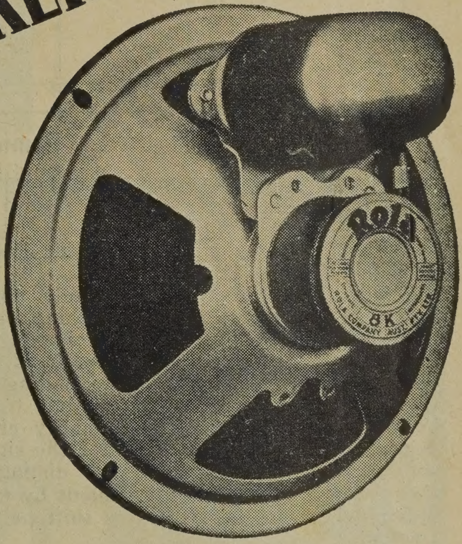

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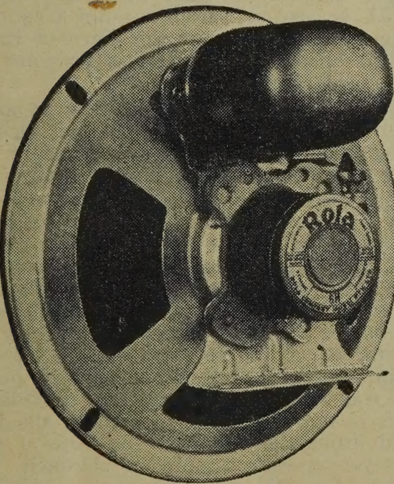

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The circuit diagram of the Vaisala radiosonde is shown in Fig. (1).

THE GERMAN RADIOSONDE

The radiosonde that was in general use by the Nazi army and navy meteorological services was the Kriegsmarine R.S.3. This is also a variable radio frequency type of radiosonde and the main point of difference between this radiosonde and previously described types is that no switching device is used to bring the meteorological elements into circuit, but instead separate radio transmitters are provided, one transmitter being used for signalling the temperature element variations and another transmitter for both the pressure and the humidity element variations. With the latter transmitter the signals sent by the pressure element could be distinguished from those sent by the humidity element by noting certain individualities in the frequency shift peculiar to each element.

The transmitters operate at mid point frequencies of 10.7 and 8 megacycles per second respectively, and the frequency variation is accomplished by arranging for the meteorological elements to alter the effective value of the inductance in the oscillator circuit of each transmitter.

The meteorological elements are all similar and consist of glass tubes containing a mercury column and fitted with a series of wire contacts fused into the walls of the tube. The rising mercury column closes these contacts which are each connected to a tap on the transmitter inductance coil, and thus the effective length of this coil is altered. The temperature element consists of a normal type of mercury in glass thermometer, while the humidity element is a wet bulb thermometer, again a mercury-in-glass thermometer with a muslin-coated bulb kept wet by a wick which feeds water from a small reservoir. The pressure element is in the form of a differential man-ometer, in which a bubble of air is trapped in a glass tube by a plug of mercury. The bubble expands as the free air pressure is reduced, and thus pushes the mercury plug up the tube.

The ground equipment for the German radiosonde employs two receivers and recorders, one for each of the transmitters aloft, and the difficulty of keeping both receivers tuned accurately to the varying signal throws a heavy responsibility on to the operator in the obtaining of accurate data.

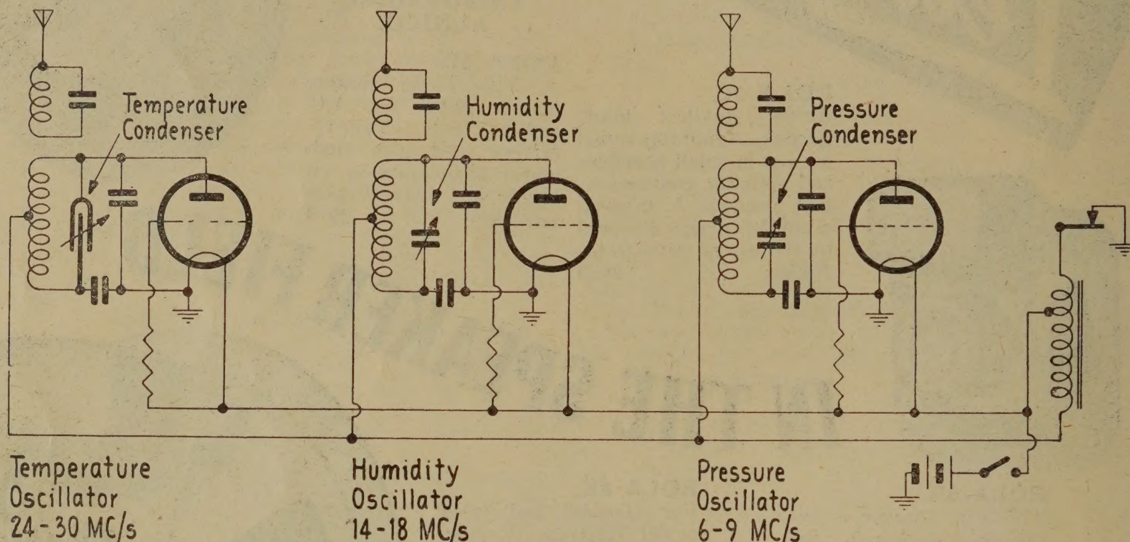


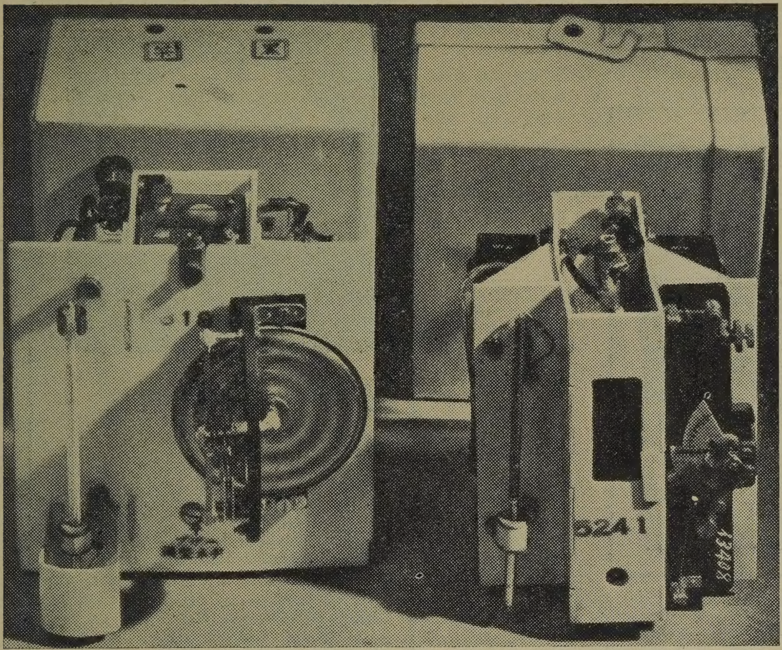
Fig. 2. Circuit diagram of the three-element Japanese radiosonde.

THE JAPANESE RADIOSONDE

The Japanese radiosonde that was used during World War II is also a variable radio frequency type, and follows the design of the German radiosonde in that a separate transmitter is provided for each meteorological element.

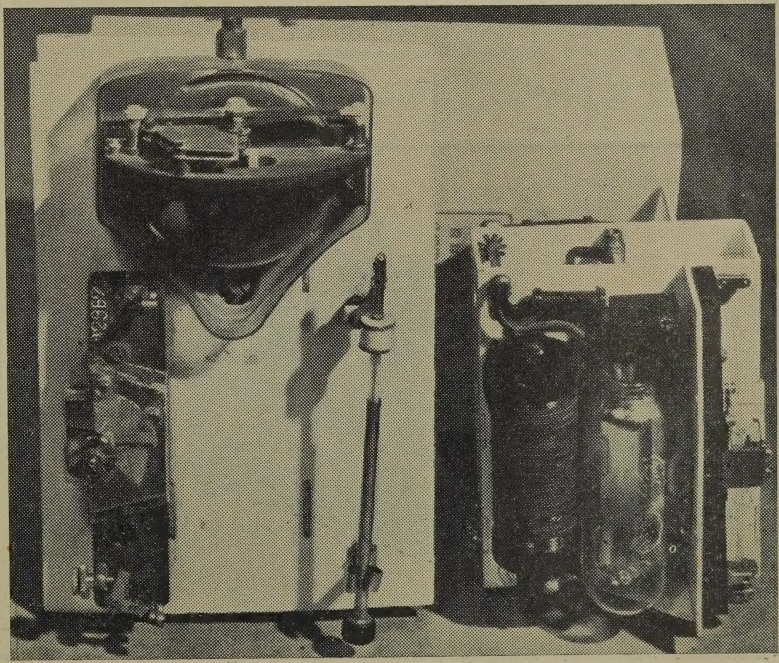
There are three different versions of the Japanese radiosonde, all having the same essential design. One version contains temperature and pressure elements only, another temperature and humidity, and a third all three elements, temperature, pressure and humidity. The first two versions each contained two transmitters, while in the third version there are three transmitters which operate over frequency ranges of 6-9 mc/s. for the humidity element, 14-18 mc/s. for the pressure element and 24-30 mc/s. for the temperature element. A novel feature is the use of a vibrator which together with a small 2 or 4 volt accumulator provides all the necessary power for the radio transmitters. As frequency modulation is employed it is not necessary to smooth the high tension output from the vibrator and thus a very light and compact power supply is obtained. The circuit diagram for the three-element version is shown in Fig. (2).

The meteorological elements operate small variable condensers which are connected across the transmitter tank coil, and so vary the transmitter frequency. The pressure element is an aneroid capsule which is coupled to the rotor of a small three-plate condenser by means of a lever and chain movement.



Left: Front views of two types of two-element Japanese radiosonde. The one on the left is the temperature-pressure and that on the right is the temperature-humidity variety.

Below: Front view of the three-element instrument and side view of the temperature-humidity two-element job. In the latter, the baseless valve can be seen with its leads directly soldered into the circuit.



The humidity element consists of a standard hair hygrometer which is again coupled to the rotor of another condenser. The temperature element is, however, of rather novel design in that an ordinary small mercury-in-glass thermometer is made to act as a variable condenser by placing a thin metal sheath over the glass tube. The mercury column, and the metal sheath act as two plates of a condenser, and as the mercury column shrinks with decreasing temperature, the capacity of the condenser decreases. A further refinement in this element is the use of an amalgam of mercury with 8 per cent. thallium which extends the range of the thermometer from $-38°$C., which is the freezing point of pure mercury, to $-58°$C., which is the freezing point of this amalgam.

The Japanese radiosonde ground equipment is very similar to that used with the other two types of frequency modulated radiosondes described in this article except in this case three receivers and recorders are required for the three-element version.

The chief disadvantage of the frequency modulated types of radiosondes as compared with the audio modulated types is that the accuracy obtainable depends too much on the personal skill and attention of the operator in the precise tuning of the receiver.

The next article in this series will deal with the chronometric type of radiosonde which is in current use by several meteorological services and which would appear to hold most promise for future development.

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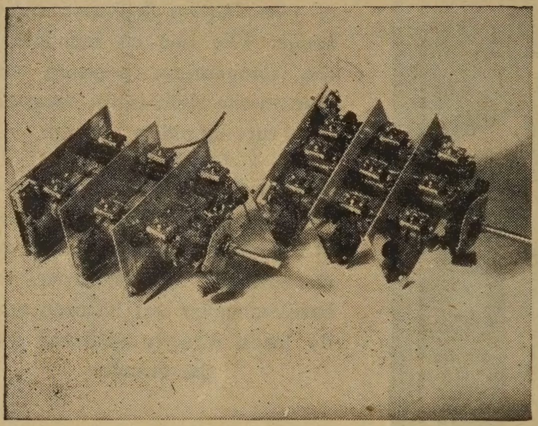

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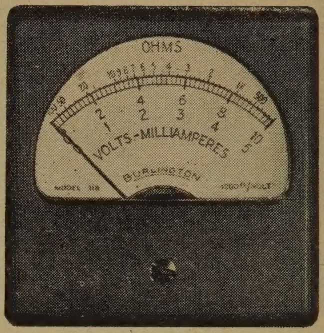

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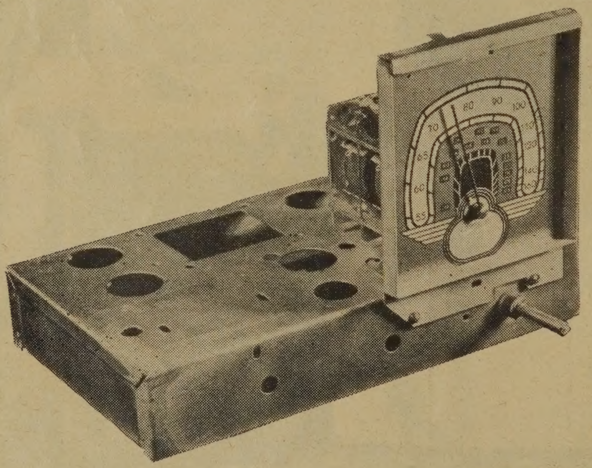

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THE PANORAMIC RECEIVER

This is yet another application of the ubiquitous cathode ray tube. It is much more than an ingenious scheme, for its use enables a number of important transmitter tests to be carried out almost instantaneously without the operator having to leave the receiver. How it works and what it can be used for are discussed in this article.

USES OF THE PANORAMIC RECEIVER

Before going on to describe the functioning of this device, it may be as well to indicate some of the things which may be done with its help.

(1) The screen of the cathode ray tube gives a visual indication of the presence of any signal in an appreciable band of frequencies centred on the frequency to which the receiver is tuned. The latter is always represented by a certain spot on the tube face, so that the panoramic tube may be used as a visual tuning indicator.

(2) On account of (1), it is possible to observe what frequencies are occupied by signals, and where the clear spots are, if any. Within the band covered by the panoramic unit this can be done **without altering the tuning of the receiver.** In short, signals within, say, plus or minus 50 kc/sec. of the receiver tuning frequency can actually be searched for signals while a station is being copied.

(3) Frequency-shift of a transmitter being keyed may be observed visually. This applies equally well to one's own transmitter or to a distant one.

(4) Carrier-shift on modulation of a phone transmitter may be observed and estimated.

(5) Incorrect neutralisation of a C.W. transmitter may be observed, and the correctly neutralised condition arrived at by observation of the C.R.T. picture.

(6) Sideband "splatter" of an over-modulated phone transmitter may be observed and corrected.

(7) Visual indication of the tuning of one's transmitter to the receiver is obtained. Similarly, the transmitter may be tuned to the frequency of a clear channel without first searching the band with the receiver.

(8) The wavemeter (**not** an absorption type) may be used in conjunction with the panoramic receiver to set the transmitter to zero beat with the former, or with any signal that is observed on the C.R.T. screen.

(9) The wavemeter may be used to measure the frequency of any signal on the screen without altering the receiver tuning.

(10) It is possible to tell at a glance whether a signal is an image response or not.

This list does not pretend to be exhaustive, but indicates the great possibilities of the panoramic receiver in amateur or commercial communications work.

HOW IT WORKS

In principle, the panoramic receiver is exactly similar to the use of the oscilloscope and a frequency-modulated oscillator in visually aligning receiver circuits. For this reason, the name of "panoramic receiver" is somewhat of a misnomer, for a complete panoramic receiver requires (1) an already complete communications superhet. and (2) a panoramic adapter unit.

The scheme of the adapter is shown in block form in Fig. 1. From the main receiver, the panoramic unit is fed via a small coupling condenser, brought from the plate of the mixer tube. This condenser is only a few micromicrofarads in value, and so does not upset the tuning of the I.F. transformer in the plate circuit of the main receiver's mixer. The panoramic unit therefore starts off with a 465 kc/sec. I.F. transformer. The output of this feeds into a second oscillator-mixer system which converts to a second and lower I.F., usually of the order of 100 kc/sec. After this comes a stage of I.F. at this frequency, followed by a diode detector which feeds through an amplifier (not shown) to the Y plates of the oscillator tube.

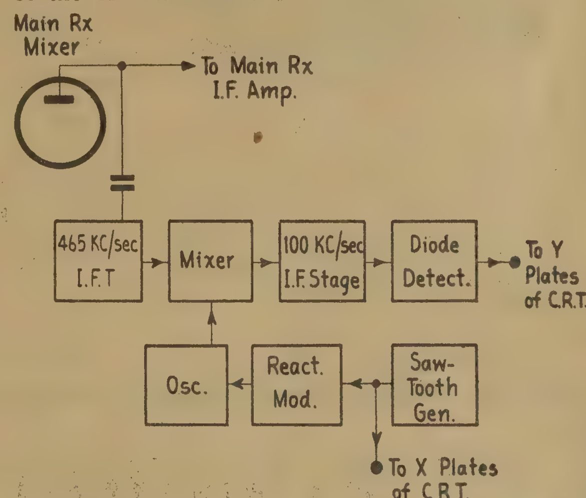


Fig. 1. Block diagram showing the main components of the panoramic system.

Also included in the unit is a time-base generator, giving a saw-tooth at some low frequency, usually between 25 and 50 cycles per second. This saw-tooth is fed to the X plates of the C.R.T., where it produces a linear time sweep in the usual manner. At the same time, however, the saw-tooth is fed to a reactance tube modulator which frequency modulates the oscillator of the second frequency conversion system.

Suppose, for the sake of argument, that the second oscillator works on the frequency of 565 kc/sec., giving a 100 kc/sec. output when mixed with a 465 kc/sec. input from the main receiver.

Now, if the reactance tube frequency modulates the oscillator to the extent of plus or minus 20 kc/sec., its frequency will vary from 545 to 585 kc/sec. and back again, once for every cycle of saw-tooth voltage applied to the reactance tube modulator. When the second oscillator is at 545 kc/sec. it will beat with any signal from the main receiver, which has been converted by the first mixer to a frequency of 445 kc/sec. Similarly, when the second oscillator is at 585 kc/sec., there will be a signal in the 100 kc/sec. I.F. channel if the main receiver is producing a signal from its mixer at

485 kc/sec. Also, when the second oscillator is at the centre of its swing, i.e., on 565 kc/sec., the signal in the end I.F. channel will be derived from a main receiver signal which is exactly on the nominal I.F. of 465 kc/sec.

It might be asked at this point, "How will the main receiver pass to the panoramic unit signals as far off the I.F. of 465 kc/sec. as 445 and 485?" The answer lies in the manner in which the input transformer to the panoramic unit is tuned. This is illustrated in Fig. 2.

centre of the tube. When the saw-tooth voltage has its average value, the spot is in the centre, but when the saw-tooth voltage is positive or negative with respect to this centre value, the spot will be either at the left or right of the centre. The timebase is, in addition, connected to the C.R.T. in such a way that as the slow rise in voltage occurs the spot moves from left to right.

At the same time, the second oscillator is being frequency-modulated by the saw-tooth timebase voltage in such a way that when the spot is at the left

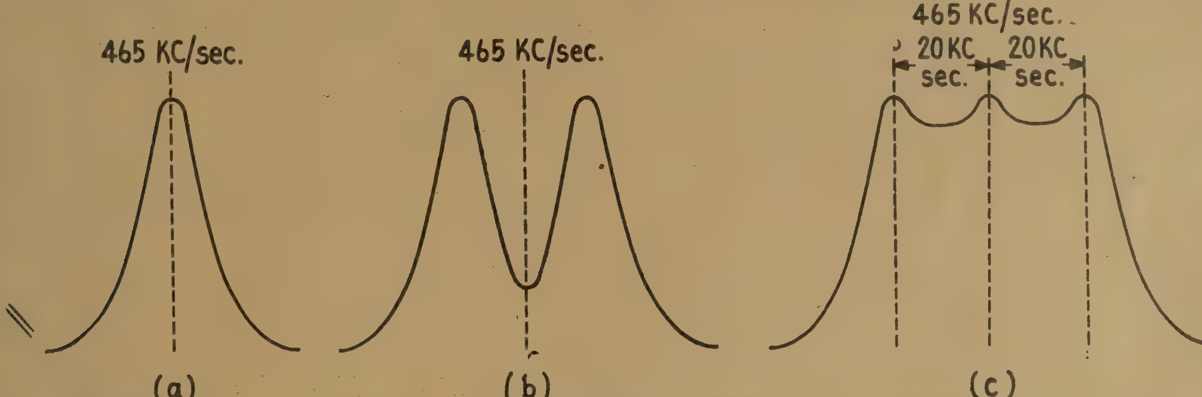


Fig. 2. Selectivity relationships at the input of the panoramic unit. For explanation see text.

It should be remembered for a start that the selectivity at the mixer plate in the main receiver is not very great, being only that due to the primary winding of the first I.F. transformer. This selectivity is represented in Fig. 2 at (a). Now, the input transformer of the panoramic unit is not tuned exactly to 465 kc/sec., but the windings are individually detuned by about 20 kc/sec. one on either side of 465 kc/sec. Thus, the response of this transformer is somewhat as in (b). Thus, when the output from the receiver mixer is fed to the input transformer, the overall frequency response is similar to (c), which shows that, although the response is not completely flat, it is so within a few decibels, over a range of plus or minus 20 kc/sec. about the centre frequency of 465 kc/sec.

In this way, the panoramic unit will receive any signals that are within this band.

Now, since the output of the main receiver is fed to the panoramic unit after frequency conversion to the 465 kc/sec. I.F., the band accepted by the panoramic unit is always of the same width, irrespective of the signal frequency. In other words, whether the receiver is tuned to 1 mc/sec. or 30 mc/sec., the signals received by the panoramic unit are always from + 20 to — 20 kc/sec. about this frequency.

Now, to go back to where the operation of the frequency-modulated oscillator was being considered, we have Fig. 3. which shows what happens at the cathode ray tube screen. The upper wave form is that of the saw-tooth oscillator, which, as previously stated, is fed to the X plates of the C.R.T.

The saw-tooth waveform causes a horizontal line to appear on the face of the tube. This line is made by the spot being deflected at a steady rate according to the saw-tooth voltage, so that the waveform at the top of Fig. 3 can represent both saw-tooth voltage and deflection, since the two are directly proportional. The undeflected spot would lie in the

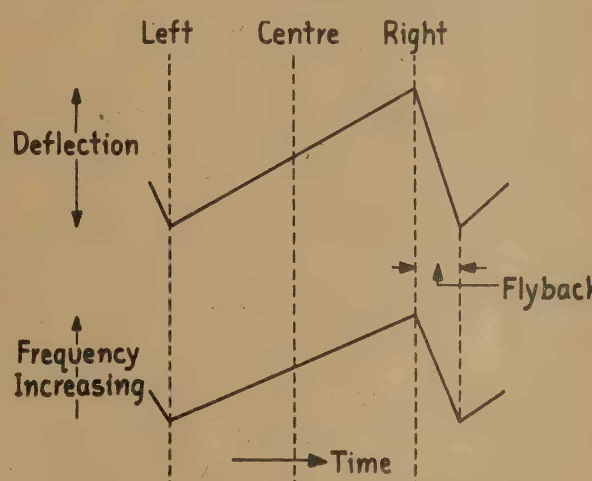


Fig. 3. Showing the relationship between C.R.T. deflection and the frequency of the F.M. oscillator in the panoramic unit.

of the tube the oscillator is at the lowest frequency of its swing. Thus, the centre of the trace will represent the centre frequency of the oscillator, and the right-hand end of the trace the highest frequency of the oscillator.

Thus it can be seen that it is possible to calibrate the trace in terms of frequency, and since the vertical or Y deflection is taken from the detector of the 100 kc/sec chain the vertical axis on the C.R.T. face will represent signal amplitude. This is exactly the state of affairs when a wobbulated oscillator and a 'scope are used to draw the response curve of a receiver for alignment purposes. In this case, the

picture is a graph of amplitude against frequency, and its shape for each signal is that of the response curve of the 100 kc/sec. I.F. channel.

This is depicted in Fig. 4, which shows a signal exactly tuned in on the receiver. Since this is the case, the peak of the response curve is at the centre of the trace. If any other signal were present within the pass band of the panoramic unit, it also would show up as a response curve on the trace, displaced from the centre by an amount proportional to the difference between its frequency and that of the signal to which the receiver is tuned.

EFFECT OF TUNING THE RECEIVER

As the receiver tuning is varied, the signal deflections on the C.R.T. move along the trace in a direction which depends on the direction in which the receiver is being tuned. For instance, if the receiver is tuned from a low to a higher frequency, the signals will move along the trace from right to left and vice versa.

In case some may have difficulty in seeing why the centre of the trace should represent the frequency to which the receiver is tuned, it should be mentioned that this is purely a function of the tuning of the modulated oscillator. Assuming that the frequency sweep of the oscillator is a linear function of time (which will be the case if both saw-tooth and modulator tube are linear in their characteristics), and also that the I.F. amplifier is correctly tuned to 100 kc/sec., then the correct condition obtains automatically **as long as the** F.M. oscillators' centre frequency is correctly tuned to 565 kc/sec. If not, the frequency sweep will still be approximately 40 kc/sec. wide, but will be between, say, 540 and 580 kc/sec., which would put 565 kc/sec. approximately 5 kc/sec. to the left of the centre of the trace.

CONTROLS OF THE PANORAMIC UNIT

The panoramic unit usually has a number of controls, some of which are pre-set and others which are brought out to the front panel. The usual front-panel controls are (1) gain (of the 100 kc/sec. I.F. channel), (2) sweep width, (3) brilliance, and (4) focus.

The two latter are the usual C.R.T. controls. The gain control is of great assistance in using the unit on signals of varying signal strengths, as it is clearly impracticable to apply A.V.C. to it.

The sweep width control varies the saw-tooth amplitude fed to the reactance tube modulator. In effect, this varies the frequency scale of the C.R.T. trace by altering the amount of the oscillator's frequency swing. The sweep width control is sometimes calibrated in terms such as ±5, ±10, ±20 kc/sec. In other cases, the amount of frequency sweep is fixed by a present control, and a permanent scale placed on the face of the C.R.T. calibrated in kc/sec. on either side of the centre.

The pre-set controls are: (1) Input transformer tuning, (2) F.M. oscillator tuning, (3) C.R.T. sweep amplitude, (4) saw-tooth input to the reactance tube. The first of these is self-explanatory, and the second has also been explained. The third is pre-set rather than a front-panel control because on it the frequency calibration of the trace depends. There is usually a pre-set control such as (4) even if a sweep width control is incorporated on the front panel. The pre-set control is used to adjust the sweep to the correct value on the maximum position of the panel control, so that the calibration on the latter holds with reasonable accuracy.

ALIGNMENT PROCEDURE

Alignment of the panoramic unit is quite straightforward, but involves a few steps not encountered in the alignment of a normal receiver. The first step is to align the 100 kc/sec. I.F. stage with the aid of a signal generator. The C.R.T. can be used as an output indicator by rendering the F.M. oscillator inoperative and employing audio modulation on the signal generator. The modulation then shows as the 400 c/sec. waveform on the trace, the amplitude being used as an output indicator.

The next step is to adjust the centre frequency of the F.M. oscillator. This can be done by feeding in a 465 kc/sec. signal to the grid of the panoramic unit's mixer tube and tuning the oscillator (with the frequency modulation applied) until the response curve is centred on the trace. All that remains to be done after this is to adjust the 465 kc/sec. double-humped input transformer. This is best done with the panoramic unit attached to the receiver with which it is to work. The connection is made and the whole I.F. amplifier of the main receiver is accurately lined up so as to remedy any detuning caused by the connection of the panoramic unit. Now a signal at 445 kc/sec. is fed into the grid of the main receiver's mixer, and one trimmer of the

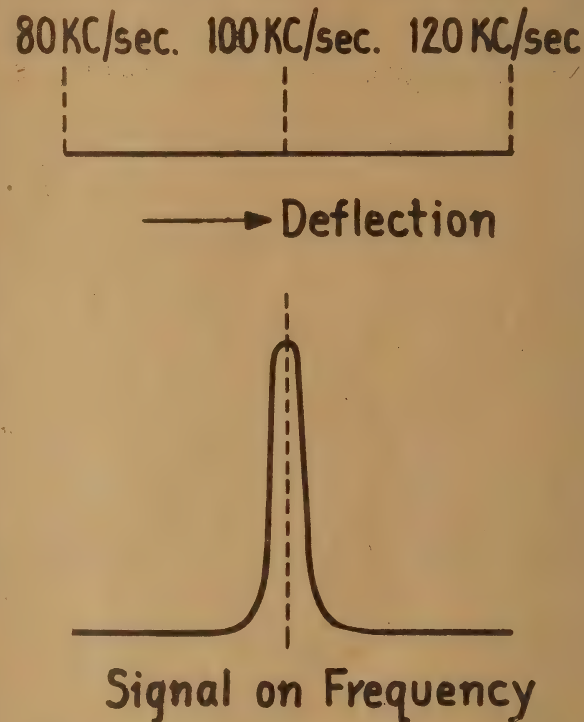


Fig. 4. Showing the appearance of a signal on the C.R.T. when the former is tuned in accurately on the receiver. Above is the fundamental frequency scale of the C.R.T. trace. The arrow shows the direction of spot movement in making the trace.

double-hump transformer is tuned for maximum output on the C.R.T. screen. Next the signal generator is retuned to 485 kc/sec. and the other trimmer of the transformer is adjusted for maximum output on the C.R.T. Now, if the signal generator is tuned over the band 445 to 485 kc/sec., the signal on the screen should not vary very much in size. In practice, the tip of the response curve will trace out the outline of Fig. 2 (a), which is the overall response of the panoramic unit when the frequency is being swept. A certain amount of cut-and-try may be necessary with the adjustment of the input transformer to make the response as flat as possible over the required pass band, but as long as the panoramic unit's sensitivity does not vary too much over the band, the results will be quite satisfactory.

USES OF THE PANORAMIC UNIT

The main uses for the device have been described at the beginning of this article, but now that the operation of the unit has been described, it remains to indicate how all these things may be accomplished.

(1) From the description of the functioning of the unit, it can be seen that all signals within the pass band of the unit will appear on the screen of the C.R.T. A keyed signal will jump up and down in accordance with the keying, while a modulated signal will appear at the carrier frequency, with smaller deflections appearing and disappearing at the frequency of the sidebands. A transmitter that is modulated by speech or music will, of course, display sidebands out to the maximum modulation frequency on either side of the carrier.

When the screen is observed with a multiplicity of signals on it, it will be recognised why a very low I.F. is chosen for the unit's second I.F. This is because it is easier to achieve greater selectivity on the low I.F., with the result that the picture shows more discrimination between nearby signals.

Ideally, the indications on the C.R.T. should be simply vertical lines, but to realise this, the selectivity of the 100 kc/sec. I.F. channel would have to be infinite. However, high-Q circuits in the 100 kc/sec. amplifier will give ample discrimination. For instance with a Q of only 50, a single tuned circuit of this frequency would give a response curve only 2000 c/sec. wide at the top.

(2) If the transmitter being received is watched on the panoramic unit, chirps are visually observed by noting that the deflection on the screen jumps sideways, thus indicating a frequency shift. A bad chirp will show up quite readily in this manner. It does not matter whether the transmitter is a local or a distant one, for either can be checked simply by adjusting the gain of the panoramic unit to a suitable value.

(3) What is usually called "carrier shift" in relation to 'phone transmission can also be observed, since this phenomenon is an alteration of the carrier amplitude. If the modulation system and the modulated amplifier are functioning properly, the carrier amplitude remains constant, and should rise slightly when over-modulation occurs. Thus if no carrier shift is taking place, the amplitude of the carrier, as shown on the panoramic unit, will not change when modulation is impressed, but the C.R.T. deflection will act as a carrier shift indicator and show up over-modulation or so-called "downward" modulation.

(4) If a transmitter is incorrectly neutralized, the amplifier may oscillate at its own frequency (and not that of the controlling oscillator) until such time as the latter has built up enough amplitude at the grid of the amplifier to cause the oscillation to lock at the controlled frequency. This shows up on the panoramic receiver as a signal, well off frequency, which comes up when the key is depressed, and then jumps suddenly to the correct frequency. Adjustment of the neutralization can be made until this frequency jump no longer occurs.

(5) It was mentioned above that if a transmitter is modulated, the sidebands show up on either side of the carrier as extra deflections at frequencies equal to carrier plus and minus the sideband frequency. It should be realized that sidebands will show up as independent deflections on the trace only if their corresponding modulation frequencies are high enough to allow the 100 kc/sec. channel to discriminate between them and the carrier frequency. "Splatter" due to over-modulation on negative peaks, amounts to the same thing as introducing large amounts of high frequency modulation components. Thus when splatter occurs it will show on the panoramic receiver as a number of sideband deflections quite far removed from the carrier frequency. All that must be done to cure it is to turn down the microphone gain until the spurious sidebands no longer show up.

(6) Tuning of the transmitter or wavemeter to the frequency of the receiver is readily accomplished by noting when the C.R.T. deflection is centred on the trace. In the same way the transmitter may be tuned to occupy a clear channel as indicated by the panoramic unit.

(7) The panoramic unit may be used to tune the transmitter to zero beat with the wavemeter to any frequency within the range of the unit, while leaving the tuning of the receiver untouched. First of all the wavemeter is set to frequency, and a deflection therefore shows up on the screen. The transmitter's V.F.O. can then be tuned until zero beat is indicated by the C.R.T. The zero beat indication is very sensitive, as a beat of one cycle per second or even less shows up as a slow fluctuation up and down in the amplitude of the response on the C.R.T. Since the receiver tuning does not need to be touched, a clear spot on the band can be selected while a station is being copied, the wavemeter tuned to the clear spot, and the transmitter V.F.O. brought into line, still while the receiver is in use on a signal.

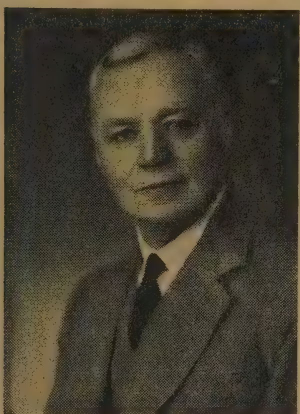
(8) Using the wavemeter to measure the frequency of a signal within the sweep of the panoramic unit may be done by observing zero beat between the wavemeter and the signal. The frequency can be estimated roughly from the panoramic unit's calibration and the receiver dial setting, or more accurately from the wavemeter setting.

(9) Identification of image responses is very easily performed. In using a panoramic unit it will sometimes be noticed that signals occur which move the wrong way along the trace. These are image responses, and behave in this way because of the fundamental fact that they are on the opposite side of the oscillator frequency from the true signals. Thus, if a signal is heard which is suspected of being an image response, a slight movement of the receiver tuning is enough to indicate whether it is an image or not.

OUR GOSSIP COLUMN

MR. C. W. RICKARD

This year appears to mark the 21st anniversary of several of the "old time" organizations engaged in the radio industry, for we find that Mr. C. W. Rickard, Director of Messrs. C. and A. Odlin Ltd. of Wellington, also has completed 21 years of active work in radio distribution.



Mr. C. W. Rickard

Born and educated in South Australia, Mr. Rickard settled in Broken Hill where he was "initiated" into the hardware trade at the age of sixteen. The following years were tough, and he learned the hard way.

As a result, at the age of twenty-one, he sought greener fields, with New Zealand as his objective. Carrying the courage of his convictions across the Tasman, he arrived in Wellington in 1905 to find that "all that glitters is not gold," and that he still had to learn the hard way.

For two and a half years Mr. Rickard was employed by George Winder, a hardware retailer occupying premises on the present site of James Smith Ltd. In January, 1905, however, opportunity really came his way, when the C. and A. Odlin Timber and Hardware Co., Ltd., launched the hardware side of its business, engaging Mr. Rickard as its first traveller. For the initial trip he carried more than other hardware travellers had ever possessed—eight cases of hardware samples mounted on boards of uniform size. From these samples, he secured indent orders from merchants, ranging from Auckland to Invercargill. As this merchandise arrived, so did other quantities of materials, and thus a hardware business which ranks high to-day had its modest beginning.

Mr. Rickard was appointed hardware manager in 1914, later becoming a Director of his present company, and in 1935 he was elected President of the New Zealand Hardware Merchants' Guild for the ensuing year.

For the past twenty-one years, C. and A. Odlin's distribution of radio receivers has been continuously under the direct and personal control of Mr. Rickard.

Late in 1925, though possessing no technical knowledge of radio, he realized the wonderful possibilities of such as a commercial proposition, and in June, 1926, launched Atwater Kent radios on this market —the first receiver (which, of course, was battery-operated) being purchased by Mr. P. R. Stevens of 2ZM Gisborne.

A year or two later saw the release of A.C. receivers—queer looking machines in metal cases, with dials like saucers, and independent speakers resembling top-hats. They were good receivers, however, and from that time forward Atwater Kent flourished throughout the Dominion, until in June, 1936, distributors and dealers alike in all parts of the world received a severe blow through Mr. Atwater Kent's decision to retire from business. Having accumulated a huge fortune, he would not permit his name to be used by other manufacturers, thereby allowing precision merchandise, together with such a well-known and highly regarded trade-name, to fade from existence.

Following this temporary set-back, Mr. Rickard was on the first boat for the U.S.A., and soon had his dealer organization again happy with Zenith, another leader in the radio field.

Early in 1938, when English receivers became more attractive in design, performance and price, Mr. Rickard was about to sail for England for the purpose of contacting English producers, when his company was indeed fortunate to secure the distribution of Mullard receivers. This distribution has been actively and successfully pursued since, with the exception, of course, of the enforced period of non-production of home radios for three years during the war.

Mullard valves are also under the same control, and although up to the present time have been largely confined to receiving types, they will shortly include a complete range of the latest transmitting types for amateur use.

During intervening years between the two wars, Mr. Rickard travelled extensively overseas in the interests of his firm. In addition to the United Kingdom and the Continent, his travels have included the Scandinavian countries.

During these visits, he has been privileged to attend three of the world's great Trade Fairs—the B.I.F., Leipzig and Paris. Five trips to America and Canada, including three visits in three successive years, have designated him "The Commuter" by his many acquaintances in the latter two countries.

In the belief that business and pleasure are just not compatible when abroad, Mr. Rickard declares that his only real holiday over a period of many years was a three months' sojourn to Java, Bali and Singapore in 1939, which terminated just a month prior to the commencement of hostilities in Europe.

We join Mr. Rickard's many friends from Bluff to Kaitaia in felicitating him on his twenty-one years' service in the radio industry, and 40 years of association with the C. and A. Odlin Company.

* * *

Mr. M. Bush

Manager for Bobbie Pins, Ltd., is Mr. M. H. Bush, well known in Auckland commercial and sporting circles.

Maurie Bush had many years in the importing trade, and is remembered as one of the most energetic members who ever sat on the Executive of the Auckland Commercial Travellers' and Warehousemen's Association.

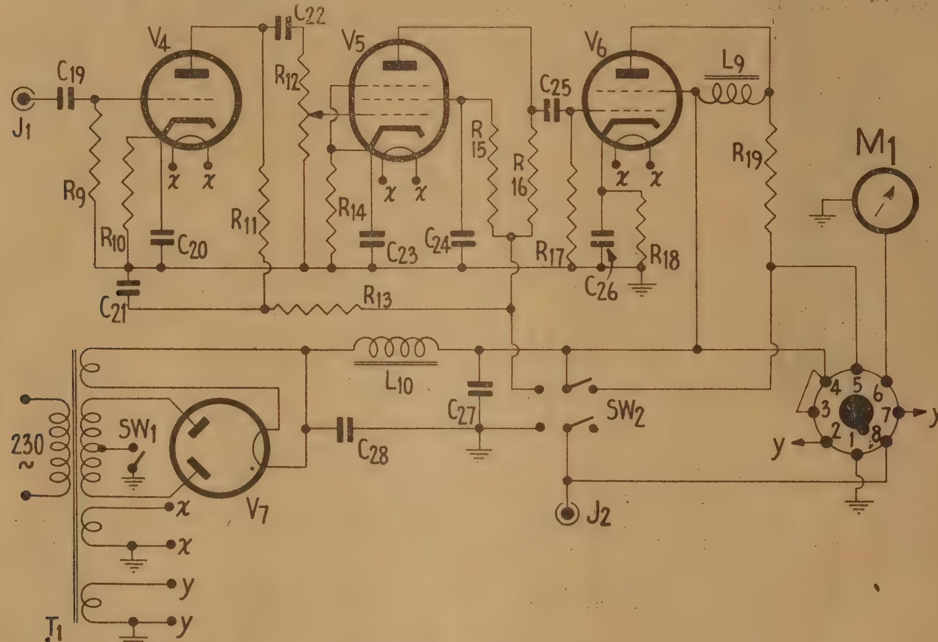
(Continued on p. 48.)

THE RADEL QRP TRANSMITTER

PART 2
POWER SUPPLY AND MODULATOR CIRCUITS

The power supply circuit is quite ordinary, and requires no special description. The transformer is rated at 385-0-385v. 150 ma. for the high-tension winding, and has two 6.3v. secondaries, one of which feeds the R.F. tubes and the other the speech amplifier and modulator circuit. The full available H.T. voltage is applied to the 6V6 modulator, V_6, through the modulation choke L_9. R_{19} serves to drop the voltage delivered to the P.A. stage through pin 5 on the octal power socket. This dropping of the H.T. voltage to the P.A. stage is absolutely essential if 100 per cent. modulation is to be attained. It is one of the disadvantages of the Heising modulation system in high-powered equipment, because of the power lost in the dropping resistor, but in a transmitter of this sort it is no disadvantage at all. It is the usual practice to bypass this resistor for audio frequencies, but here the bypass has been purposely omitted.

The screen of the P.A. stage is fed through a series resistor R_8 from the **modulated** H.T. voltage supply, and is bypassed for R.F. only by the small condenser C_{16}, which is not large enough to give appreciable bypassing at the higher audio frequencies.



COMPONENT LIST

- V_4 = 6J5 (or 6SJ7 triode)
- V_5 = 6SJ7
- V_6 = 6V6
- V_7 = 5Z3
- C_{19} = 0.01 mfd. paper
- C_{20}, C_{21} = 0.5 mfd. paper
- C_{22}, C_{25} = 0.002 mfd. paper
- C_{23}, C_{26} = 25 mfd. 40v. electro.
- C_{24} = 0.05 mfd. paper
- C_{27}, C_{28} = 10 mfd. 450v. electro.
- R_9 = 1 meg.
- R_{10} = 2500 ohms
- R_{11} = 250k.
- J_1 = microphone jack
- R_{12} = 500k. pot.
- R_{13} = 50k.
- R_{14} = 1k.
- R_{15} = 2 meg.
- R_{16}, R_{17} = 500k.
- R_{18} = 250 ohms
- R_{19} = 500 ohms
- T_1 = 385-0-385v., 6.3v., 6.3v.
- M_1 = 0-100 ma. m/c. meter
- Sw_1 = S.P.D.T. T/R switch
- Sw_2 = D.P.D.T. phone/C.W. switch
- L_9 = 30H. 150 ma. mod. choke
- L_{10} = 20H. 150 ma. choke
- J_2 = key jack.

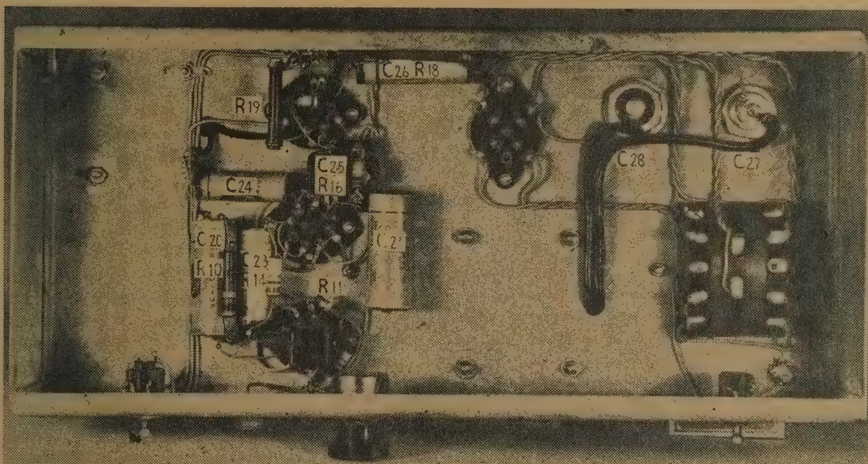
SPEECH AMPLIFIER

The speech amplifier consists of the 6SJ7, V_5, preceded by a medium mu triode V_4. This arrangement has enough gain to modulate the transmitter fully from a crystal or dynamic microphone. If a high-

level microphone is to be used, V_4 may be omitted and input applied directly to V_5.

The gain control has been placed between V_4 and V_5 so as to eliminate the noise which might occur on moving the control if this were at the input of V_4. The latter tube can never be over-loaded by a low-level microphone, so that there are no disadvantages in putting the control in this position.

The circuit constants through the speech amplifier circuit have been chosen to give a restricted high and low frequency response. This is quite important, as there is no point in having a "high fidelity" audio channel. In fact, there are grave objections to such a system in a transmitter intended for speech and not music. Background noises tend to be most troublesome at low and high frequencies—particularly the former—and if there is much background, this can severely limit the speech level that can be applied before audio overloading or 100 per cent. modulation is reached. Attenuating the low and high speech frequencies gives greater intelligibility, both through allowing the actual speech modulation to be at a higher level, and through removing the background noise at the source, as it were.



Underneath view of the modulator and power supply. The top view was used as our cover picture in last month's issue. The three sockets in a row are for V_6, V_5 and V_4 respectively, reading from back to front. The left-hand switch is the phone/C.W. switch while the right-hand one, Sw_1, cuts the H.T. to the whole transmitter for stand-by.

PUTTING THE TRANSMITTER INTO OPERATION

If the transmitter has been constructed as per specifications, no difficulty should be experienced in putting it into operation. The coil specifications given should not cause any difficulty in locating the 80m. band, and no adjustments should be necessary except possibly to L_1. This is because C_1 and C_3 have been chosen so that with the correct value of L_1, C_2 just spreads the 80m. band nicely over the whole dial. However, the specified coil should be sufficiently close to requirements for a turn or two either way to put the band right where it is wanted. Since the oscillator operates on 160m. for the 80m. band, it will be better for frequency checking with the absorption wave-meter if V_2 is operating also. In fact, there is no reason why the whole R.F. end can not be run (without an aerial, of course) when the frequency check is being made.

At first turning on, C_2 should be set at about the centre of its scale, A lamp indicator is then coupled to the plate tank of V_2, and C_{12} is tuned for maximum output. The indicator is then transferred to the V_3 tank circuit and C_{18} is tuned for maximum brilliance. In tuning up a pentode amplifier such as this one, it is much better to tune for maximum output rather than for minimum plate current, especially when the transmitter is loaded.

When the transmitter has been tuned up in this way, the frequency should be measured with whatever equipment is available, and should turn out to be somewhere near the centre of the 80m. band.

The transmitter tuning is now altered in small steps until C_2 is fully meshed, and the frequency at this end of the dial is measured. If it is too high, so that a small portion of the band is off the oscillator tuning range, the inductance of L_1 should be increased, either by adding a few turns or by squeezing the turns a bit closer together. If the frequency is lower than 3.5 mc/sec., the transmitter is now tuned up on the high-frequency end of the oscillator range, and the frequency is measured again. If the measured frequency is now less than 3.96 mc/sec., the coil inductance is a little too high. However, a little adjustment in this way, with C_1 and C_3 remaining fixed at the values given in the component list, should enable full bandspread on 80m. to be realised quite readily.

AERIAL COUPLING

L_8, the aerial coupling coil, has been specified on the assumption that an aerial tuner will be fed from it via a low-impedance link. For this reason, fixed coupling to the final tank has been shown. Any of the aerial tuning or coupling schemes given in the amateur literature may be used successfully with this arrangement, the variation of coupling between aerial and final tank coil being accomplished by varying the tapping points at the aerial tuning device.

MODULATION

For phone use, the aerial coupling should be adjusted to make the final amplifier draw a plate current of 40 ma. This ensures that both the plate input power and the final's input impedance as seen by the

modulator are such that the latter is capable of modulating the carrier 100 per cent., with good quality of output.

If the aerial coupling is tightened and the final plate current pulled up to much more than 40 ma., the power input will be too great for 100 per cent. modulation to be obtained from the modulator power available. This is no advantage at all, as decreasing the modulation capability more than offsets the very slight advantage gained by pushing an extra fraction of a watt into the final amplifier.

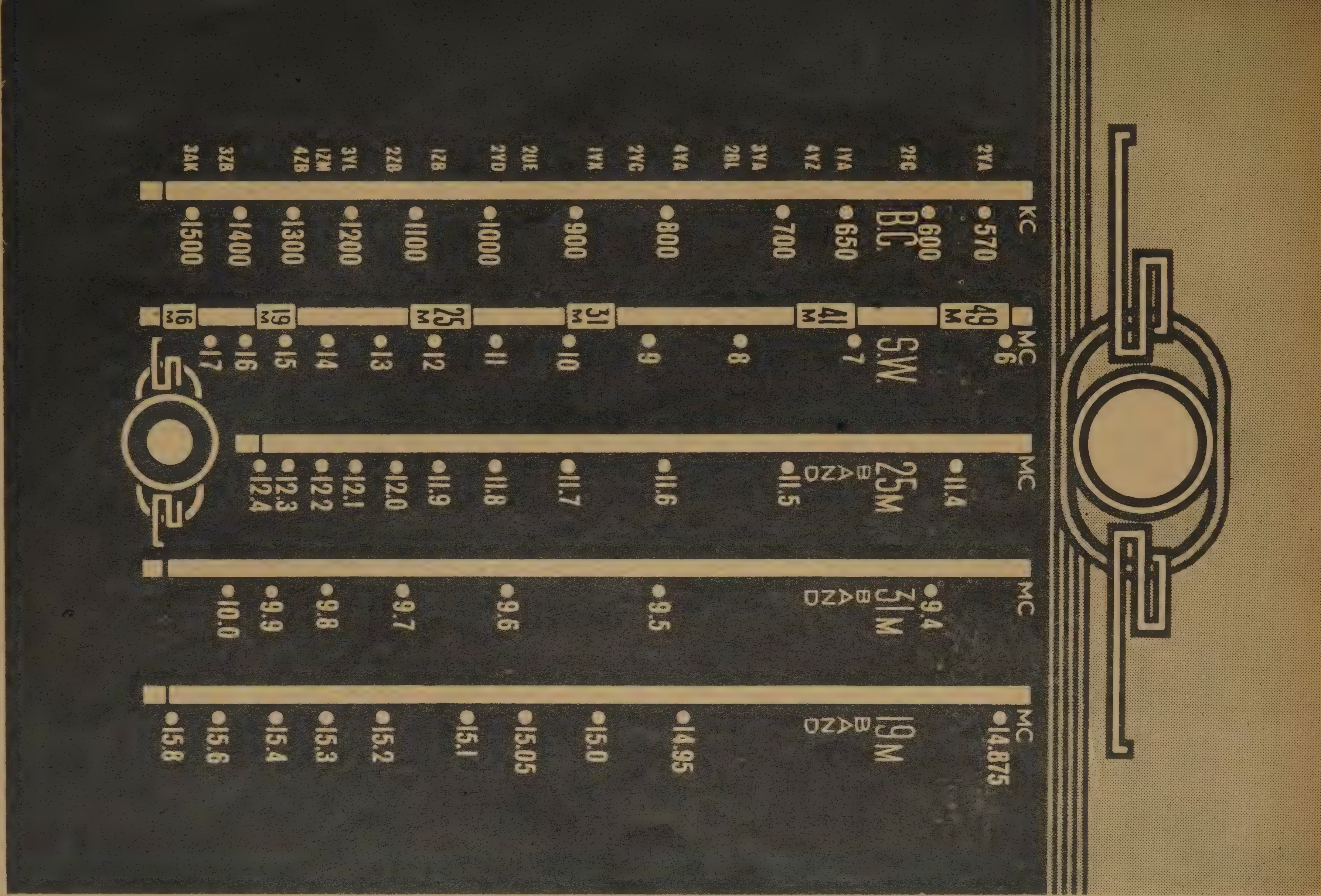
If you are the proud possessor of an oscilloscope, it should be attached to the transmitter so as to give a trapezoidal modulation picture. The microphone is then connected, the audio gain control advanced, and a few test words spoken. It should be noted that on speaking loudly, the picture does not come quite to a point, indicating that 100 per cent. modulation is just not reached on the negative half-cycles of the speech waveform. This is a very valuable feature, since it means that however loudly one speaks, the carrier is never quite cut off, and the greatest single source of over-modulation "splatter" is removed. The final amplifier in this transmitter is capable of somewhat more than 100 per cent. modulation in the positive direction, so that on over-modulation there is a cushioning effect, due to the negative peak limiting action, and quite heavy over-modulation can be indulged in before the speech distortion as shown up in a receiver is too great for comfort. This property is a decided asset, as it is possible to keep "punching" the modulation well up, and so getting the greatest possible range out of the comparatively low power available, without cluttering up the band with a distorted signal or, which is more important, with sideband splatter.

MICROPHONE PHASING

Since the modulation system used here gives the effect of a negative-peak modulation limiter without one having actually been incorporated, it is possible to keep the average modulation percentage quite high by properly phasing the microphone.

Microphone phasing depends for its usefulness on the fact that speech waveforms are irregular, unlike sine-wave and musical waveforms. That is to say, the peaks on one side of the zero-line are greater in amplitude than the peaks on the other side. Now, this transmitter, in common with all other (plate-modulated ones), is limited to 100 per cent. modulation in the negative direction, but will handle more than 100 per cent. in the positive direction. Thus, if the microphone is connected to the speech amplifier in such a way that the smaller peaks, when observed at the modulator plate, are in the negative direction, then the fullest possible use is made of the carrier. For, if the larger audio peaks at the modulator plate are in the negative direction, then 100 per cent. modulation is reached in this direction long before the maximum positive modulation capability has been reached. But if the recommended

(Continued on page 47.)



An actual size reproduction of the attractive glass dial which is etched in six colours. There is a different colour indicator for each scale. The De Luxe Band Spread Tuning Unit also incorporates the following features: (1) Completely aligned and tested before leaving factory; (2) spin tuning, provision for magic eye, and Plessey Isolantite gang condenser; (3) has broadcast band. Short-wave band 16 to 49 metres with 19, 25, and 31 metres fully spread. Total height from top of dial to bottom of chassis, 12 in. Obtainable only from S.O.S. RADIO LTD., 283 Queen St., Auckland.

TUBE DATA: (I) CALCULATING THE TRIODE CHARACTERISTIC OF PENTODES

In a recent issue of "Radiotronics" is to be found a procedure for finding the characteristics of a pentode when it is connected as a triode, i.e., with plate and screen tied together. The ability to perform such calculations, which are quite simple and straightforward, is a decided asset in a variety of circumstances. For example, it is frequently desired to design equipment using a minimum number of valve types so as to make replacements more easily obtained, or in order to use valves which are available. Again, suppose it is required to design a voltage amplifier comprising two stages of resistance-coupled pentodes and a resistance-coupled triode stage, one proviso being that each stage must use the same valve type—say, 6SJ7.

This problem is easily tackled until it comes to designing the triode-connected stage, since little or no data exist on type 6SJ7 connected as a triode. Since curves are not available for the tube in this connection, the stage would have to be designed by purely "cut-and-try" methods were it not possible to work out the triode constants of the 6SJ7, which, although not much, are a far better starting-point than no data at all.

The above is only one example of the usefulness of the method to be described.

Principle of Calculation

When a pentode is used in its normal pentode connection, the total cathode current, Ik, divides between the screen and plate such that

$$Ik = Ig_2 + Ip \quad \ldots\ldots \quad \ldots\ldots \quad \ldots\ldots \quad (1)$$

where Ig_2 is the screen current and Ip is the plate current. It has been found that the triode mutual conductance and the pentode mutual conductance are in proportion to the total cathode current and the plate current respectively, so that we have

$$\frac{gt}{gm} = \frac{Ik}{Ip} \quad \ldots\ldots \quad \ldots\ldots \quad (2)$$

where gt is the triode mutual conductance and gm is the pentode mutual conductance.

This formula is strictly accurate only when gm, Ig_2, and Ik are given for the condition where plate and screen voltages are equal. In many cases, this condition does not obtain for the figures quoted in the valve data, but this drawback may be overcome by noting that if the screen voltage is held constant and the plate voltage is varied, the plate current remains substantially constant. Thus, no very great error occurs if the calculation is performed using figures for gm, Ik, and Ip given for plate voltages higher than the screen voltage.

Some Examples

Suppose, as above, we wish to find the triode characteristics of a 6SJ7. From the valve manual, we find that a 6SJ7 with 100 volts on plate and screen and a grid bias voltage of -3 has the following characteristics: $gm = 1575$ micromhos, $Ip = 2.9$ ma., and $Ig_2 = 0.9$ ma. Thus $Ik = 2.9 + 0.9 = 3.8$ ma.

Substituting in equation (2) we have:

$$gt = \frac{Ik \times gm}{Ip} = \frac{3.8 \times 1575}{2.9} \text{ micromhos}$$
$$= 2064 \text{ micromhos}$$

Thus, the mutual conductance of the 6SJ7 is 2064 micromhos (or 2.064 ma/v.) with 100 volts on the plate and -3v. on the grid.

To take a further example, suppose we wish to know the triode mutual conductance of a 6AC7/1852. The figures quoted for this type in the valve manual are $Ip = 10$ ma., $Ig_2 = 2.5$ ma., $gm = 9000$ micromhos, when the plate voltage is 300, the screen voltage is 150, and the grid bias voltage is -2v. We assume now that if the plate voltage is reduced to 150, the plate current will remain unaltered, and reference to the curves for the 6AC7 shows this to be very nearly the case. Thus, as before, we have

$$gt = \frac{Ik \times gm}{Ip} = \frac{12.5 \times 9000}{10} \text{ micromhos}$$
$$= 11{,}250 \text{ micromhos or } 11.25 \text{ ma./v.}$$

Calculating Triode Amplification Factor

If this is not given in the valve manual, it also may be calculated, although the answer is subject to a little more error than the calculation of mutual conductance. Reference is again made to the pentode operating characteristics, the required information being ec.o., the negative grid voltage at which the plate current is just cut off, and eg_2, the screen voltage. If these are known, the triode amplification factor, μt, may be found from

$$\mu t = eg_2/ec.o. \text{ approx.} \quad \ldots\ldots \quad \ldots\ldots \quad \ldots\ldots \quad (3)$$

For the purposes of equation (3), the value of ec.o. that is required is not, in general, the value given in the valve manuals. This is because equation (3) assumes that the Ip-eg curves are straight, whereas in practice a pronounced bottom bend occurs. Thus, the correct value for ec.o. is less than the quoted figure. The best procedure is to draw from the plate characteristic curves a curve of plate current against grid voltage. Then at the point on this curve representing the required operating grid voltage, a tangent is drawn to cut the eg axis. The value at which it cuts is ec.o. for the purposes of equation (3). An alternative but less accurate method is to use the value which is labelled on the lowest curve in the plate family given in the valve manual. This value is somewhat less than the actual cut-off bias, and so is more likely to be a good value to use than is the actual cut-off bias quoted in the tables.

As an example let us again take the 6AC7. The lowest curve on the plate family given in the manual is that for $eg = -4$ volts, so that we will take $ec.o. = 4$. Thus, equation (3) gives:—

$$\mu t = eg_2/ec.o. = 150/4 = 37.5.$$

To illustrate further, it is found, by reference to the larger loose-leaf bound hand-book put out by R.C.A. that a curve is given for Ip against eg. Now drawing a tangent to this curve at the point $eg = -2$v., gives a value of -3.75v. for ec.o. Using this in equation (3) gives a value of 40 for the triode amplification factor, so that the original estimate by the rough method was not very far out after all.

PLATE RESISTANCE

Once the mutual conductance and amplification factor have been found, the triode plate resistance may be calculated from them in the usual way, the formula being:—

$$rp = 1000 \ \mu t/gt \quad . \ . \ . \ . \ . \ . \ . \quad (4)$$

where rp is in ohms and gt in ma/v.

Thus for the 6AC7, in which $\mu = 40$ and gt = 11.25 ma/v., we have:—

$$rp = 1000 \times 40/11.25 = 3,555 \text{ ohms.}$$

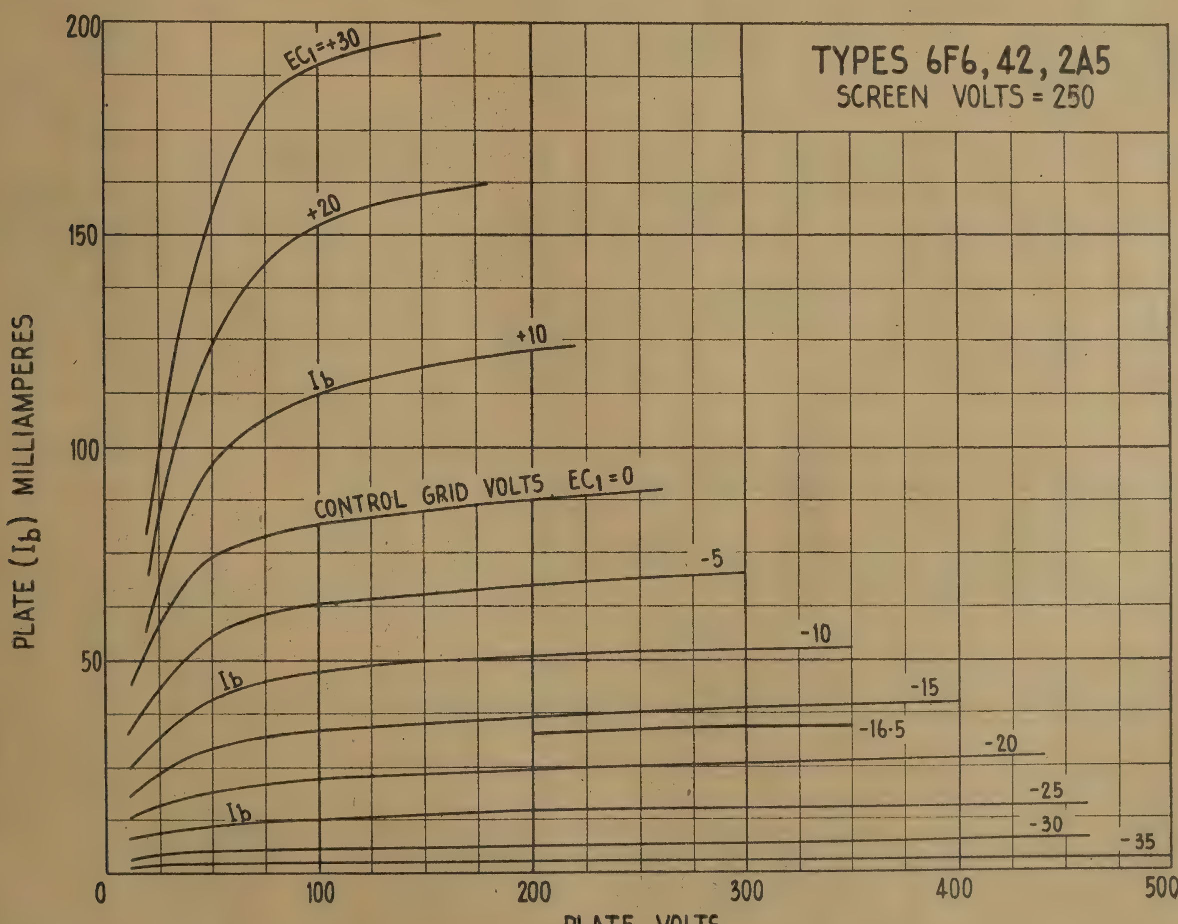
One very valuable use to which the calculation of triode mutual conductance can be put is that of testing pentodes on a home-made mutual-conductance bridge. Such an apparatus can be constructed very simply, and used for both triodes and pentodes as long as the latter are triode-connected. The difficulty in this case is to know what mutual conductance the pentodes should have where operated as triodes. The above calculation will serve quite well as a basis for testing pentodes in this way.

(2) PLATE CHARACTERISTIC CURVES FOR TYPES 6F6, 42 OR 2A5

Continuing our series of curves for well-known tubes, drawn to a more suitable scale than is usually found in the valve manuals, we have those for the above types. The curves apply to a screen voltage of 250, and so may be used for any plate voltage between 250 and the maximum allowable of 375. The maximum plate dissipation for these types is 11 watts and maximum screen dissipation is 3.75 watts.

The curves will be most useful for calculating the required load resistance and the harmonic distortion obtained with plate voltages not given in the manuals as "typical operating conditions."

Three curves are included for positive grid conditions so that the family may be used in the graphical analysis of class AB_2 amplifiers using these valves.



QUESTIONS AND ANSWERS

THE INFINITE IMPEDANCE MIXER YET AGAIN

J.R.P., New Plymouth, writes:—

"I have used a 6SN7 as an infinite impedance mixer, but encountered trouble with squegging, and the tube running hot. I therefore changed over to a 6F8-G, but with the same results. I also find it a bit dead on short-wave, although I am using a 6AC7 R.F. stage and 6SK7 and EF39 I.F. stages. Could you please tell me if a 6AC7 or 6SJ7 as infinite impedance mixer, using a separate 6J5 oscillator, would give more 'pep' on short-wave reception?"

It appears from J.R.P.'s letter that his trouble is purely one of improper oscillator circuit design.

In the first place, if a 6SN7 is not working correctly, a 6F8 could not be expected to give any different results as the two types are identical except for inter-electrode capacities and for the fact that the 6F8 has one grid brought out to a top-cap.

If the oscillator is squegging or running with too much plate current the answer is most probably that the coil used gives too much feedback for the plate voltage applied, and for that the grid leak is too high in value. For these tubes we recommend a plate voltage not higher than 150 for the oscillator section, and a grid leak not greater than 25,000 ohms.

If there is any control over the construction of the tickler winding, the number of turns could be slightly reduced as well. One or more of these modifications should produce a good, stable oscillator.

The question of lack of sensitivity is a more difficult one. The infinite impedance mixer certainly has less conversion gain than conventional circuits, but if the rest of J.R.P.'s line-up is working correctly, he will have more than enough gain even with the weakest signal.

As we have said before, absolute sensitivity matters very little indeed if the sig./noise ratio is good. In addition, a set with very good performance in this respect sounds as though it has not much gain **until** a signal comes in!

We do not think there would be any appreciable advantage in using a 6AC7 or 6SJ7 with separate oscillator—certainly not so far as sensitivity is concerned.

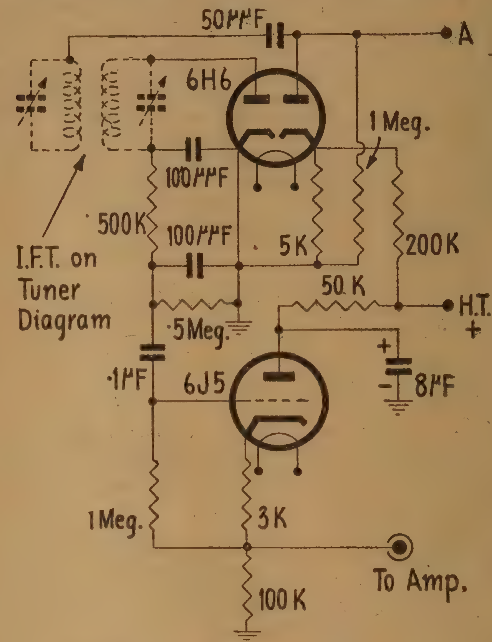
FEEDING A TUNER TO AN AMPLIFIER

A.M.T., Waitara, writes:—

"As I am intending building the tuner section of the 'Radel Dual-wave Six' I am wondering if the modifications to the second detector circuit of the 'Bandspread Six,' given in your Questions and Answers in the July, 1947, issue are suitable for application with the Dual-wave Six, and for feeding into a volume expander and 6A3 amplifier. If this is not suitable, what arrangement would you recommend?"

The modified circuit to which A.M.T. refers is quite suitable for his purpose. In fact, it is suitable for feeding the output of any tuner to any separate amplifier. For that reason we reprint the circuit here. The point marked A is the source of A.V.C. voltage and should be connected to the A.V.C. line, which of course must include the normal audio filter.

With particular reference to the "Dual-wave Six" circuit, "A" should be attached to the diode end of R_{17}. Should it be found that there is too much audio gain with the volume expander in circuit, it would be desirable to take the receiver output from a tap on the 100k. cathode follower load resistor.



NOMENCLATURE OF VALVES

A.B.K., Wellington, writes:—

"Can you enlighten me as to why Philips-type tubes are numbered in such a haphazard way? Do the various letters and numbers mean anything at all? It seems to me that some time ago an attempt was made to adhere to a system which 'got away' owing to the large increase in new types developed."

There **is** a system wrapped up in the Philips-Mullard valve numbers and this has been strictly adhered to by these manufacturers since about 1935. The numbering is actually anything but haphazard—as the following explanation shows.

Meaning of the first letter (i.e., series to which the valve belongs):

A = old 4 volt A.C. series.
C = 200 ma. A.C./D.C. series.
D = 1.4 volt battery series.
E = 6.3 volt A.C. series.
K = 2 volt battery series.
U = 100 ma. new A.C./D.C. series.

Meaning of the second and third) letter (i.e., type of valve):

A = diode.
B = duo-diode.
C = Triodes other than power valves.
D = Triodes used as power valves.
E = Tetrodes.
F = H.F. or I.F. pentodes.
H = Hexodes.
K = Octodes.
L = Power pentodes.
M = magic eye tubes.
Y = half-wave rectifiers.
Z = full-wave rectifiers.

(Continued on page 48)

RECEIVER BIAS SUPPLIES USING PARALLEL-CONNECTED DIODES

By far the commonest method of providing grid bias for tubes in receivers is that of employing cathode resistors, bypassed for R. F. or audio. Under some circumstances, the special bias-supply circuits shown in this article may be advantageous.

The method of using self-bias resistors in almost all cases where small values of minimum bias are required has become so standardised that the possibility of using other biasing systems is often overlooked altogether. The purpose of this article is to present some bias-supply circuits which might well find application in receivers, and even amplifiers.

At first sight, the term "bias supply" may tend to cancel any advantages that may be claimed for it, calling to mind, as it does, an extra valve and smoothing components, but the fact is that both space and cost may be saved, particularly in a large receiver, by employing a suitable bias supply. We say "may" advisedly, since each case has to be judged on its merits. Of these the reader may well be left to judge for himself, so, without further ado, we will proceed to describe the circuits we have referred to.

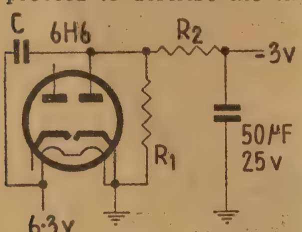


FIG. 1

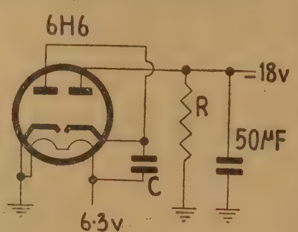


FIG. 2

SUPPLY FOR R.F. TUBES

Fig. 1 shows a circuit which may be used for providing the normal minimum bias of 3 volts negative for the R.F., I.F., and converter stages of a receiver. It uses one-half only of a 6H6, connected as a parallel, or shunt half-wave rectifier. The A.C. input voltage is 6.3, obtained from the 'high" side of the 6.3v. heater winding. This is fed to the plate of the 6H6 through a condenser C. The diode load resistor is R_1, while R_2 and the 50 mfd. low voltage electrolytic condenser act as a smoothing filter, and reduce the ripple to a very low figure. The actual output voltage may be adjusted by varying either C or R_1. However, since R_1 and R_2 in series are placed in the common grid return lead of all stages for which the system supplies bias, the sum of these two resistors is limited to a reasonably low value. For example, if bias is supplied for three tubes, each of which must have not more than 1 megohm series grid resistance, the total resistance in the common grid return lead must not be greater than ⅓ megohm. Since decoupling resistors must be used in the bias lead to each tube, their presence further reduces the allowable total of R_1 plus R_2. Thus, there is considerable virtue in reducing these resistors to as small proportions as possible, consistent with obtaining the required bias voltage of —3 and at the same time sufficient smoothing. However, the latter is partially assisted by the decoupling circuits in the grid of each tube.

For the reasons set out above,, R_1 and R_2 were set at 25,000 ohms each, and it was found that with C = 0.25 mfd. the output voltage was exactly 3-volts negative. There is a point which should not be lost sight of, and that is the leakage current of the 50 mfd. smoothing condenser. If this is too large, the supply voltage will drop considerably, and the required —3 volts will not be obtained. In this connection, it may be mentioned that in our test circuit, the smoothing condenser that was used had a measured resistance of 1 megohm, as shown by an ohmmeter, so that as long as the condenser shows a resistance equal to or greater than this when measured in this way, the output voltage will be —3 volts or very slightly more.

It is to be noted, too, that an ordinary 1000-ohm-per-volt meter can not be used to measure the output voltage of this circuit, as the shunting reduces the output voltage and the reading given is much too low. However, the figures given above for R_1, R_2, and C will provide a bias voltage that is accurate enough for all practical purposes.

A VOLTAGE DOUBLER

In Fig. 2 both halves of a 6H6 are used in a voltage-doubler circuit which will provide higher bias voltages up to about 18 volts negative, should these be required. In this circuit the actual voltage delivered depends very much on C and R and the leakage in the 50 mfd. smoothing condenser. For example, if C = 2.5 mfd. and R = 50k., a bias of —14 volts is obtained if the smoothing condenser has a measured D.C. resistance of 1 megohm. This supply is therefore suitable for providing bias for one or two 6V6's either in parallel or push-pull, with 250 volts on plate and screen.

It will be noted that higher values of R will give higher bias voltages, but in this case we have limited the value of R to 50k. because two power tubes, such as the 6V6, used in parallel or push-pull, must not have more than 50k. series resistance in the grid circuit. Thus, the circuit of Fig. 2 is suitable only when transformer coupling is used. Resistance couping would increase the actual grid resistance per tube by the value of the grid resistor, and would therefore cause the maximum allowable grid resistance under fixed bias conditions to be exceeded.

HIGHER BIAS VOLTAGES

The circuits of Figs. 3 and 4 do not suffer from the limitations imposed on the two previous circuits by reason of the low A.C. input voltage and the small allowable current in a 6H6. In these circuits a 6X5 is used, and is fed via a condenser C from one side of the high voltage winding of the power supply transformer. Thus, bias voltages up to very high values may be obtained if they are required. The parallel rectifier circuit has the advantage in these cases that the 6X5 cathode is earthed, so that an extra heater winding for the 6X5 is unnecessary. Such a winding would be necessary if the more usual series diode circuit were used.

In addition, the presence of C in the circuit enables the voltage delivered to the 6X5 to be controlled, so that the actual voltage developed at the input to the filter is very little greater than is necessary for the application in view. Because of this, series dropping resistors on the D.C. side of the circuit, together with heavy bleed currents, are avoided.

In Fig. 3 the bleeder is connected at the output of the smoothing filter, so that bled current flows

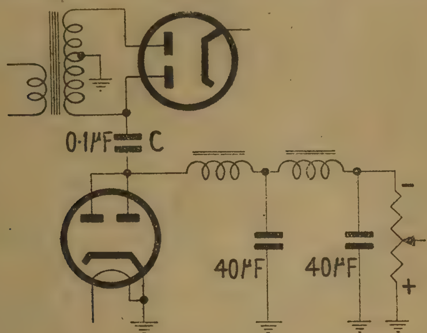


FIG.3

This circuit may be used where high-bias voltages are required. The maximum voltage available may be varied by using different values for C.

through the chokes. However, this connection allows a comparatively low-resistance potentiometer to be used as the bleeder, so that the exact bias obtained may be varied to suit requirements.

The advantage of Fig. 4 over Fig. 3 is that the bleeder R is connected at the input of the filter, with the result that no D.C. flows through the latter, and the smoothing is improved. Alternatively, smaller chokes may be used, with higher D.C. resistance, and these will give as good smoothing without reducing the available bias voltage.

A wide variety of voltages may be obtained with Figs. 3 and 4, so that it is difficult to specify circuit values for given output voltages. For this reason, a series of measurements was made with the circuits of Figs. 3 and 4, the results of which are tabulated below. In these tests, the chokes were low-resistance ones, so as to give an idea of the maximum available voltage for Fig. 3 when various values of bleeder sistor were used. In each case the smoothing condensers used were 40 mfd. 450 volt components, with the result that the smoothing for all practical purposes could be regarded as perfect. The tables given below list the output voltages available for various values of bleed resistance, and a variety of values of C.

Those wishing to use these circuits can therefore take the figures as a guide to the voltages that may be obtained under the stated conditions. The power transformer used had a nominal 385-volts-a-side, and was used in a normally loaded condition actually working in a receiver.

It will be noted that the bleed resistors used were 25k., 50k., and 1 meg. The reason for this wide variation is that the lower values are suitable where the supply is to provide bias for power triodes such as 2A3's, 45's, 50's, or DA30's, and where the maximum grid resistance per tube must be kept low. The high value shows what can be obtained when it is desired to use the parallel rectifier scheme to provide negative voltage supply for a smal cathode ray tube. In this class of service an ordinary full-wave rectifier circuit may be used for supplying the amplifier and time-base circuits, and the 6X5 parallel rectifier for the negative supply voltage required for the tube.

Another application of Figs. 3 and 4 is for direct coupled amplifier circuits where a negative supply

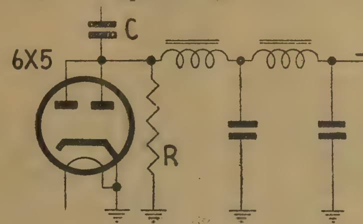


FIG.4

A variation of Fig. 3 in which the bleeder R is at the input to the filter.

voltage is required in order to place the plate of one stage at earth potential.

Fig. 3

C	Load Resistor 25k.	50k.	1 meg.
0.035	40	50	130v.
0.04	60	60	150v.
0.05	80	90	160v.
0.062	120	150	180v.
0.083	200	260	320v.
0.12	320	365	460v.
0.25	380	420	480v.

(Continued on page 48.)

SOME POINTS ABOUT SOLDERING

Although each and every radio or other electronic equipment built depends for its success on the making of perfectly soldered joints during assembly, surprisingly little is known about the mechanism of soldering by those who depend upon it for their living. This short article is intended to raise some of the most important issues involved.

It should not be necessary to enlarge further on the extreme importance of adequately soldered joints, for everyone connected with electronic equipment, in whatever capacity, actually depends on them for his livelihood.

It is generally appreciated that one of the most important causes of bad joints is the human element. However, the correct technique is easily enough learned for inefficient soldering due to this cause to be largely eliminated by the proper training of factory operatives on the one hand, and by practice in the case of individuals such as servicemen.

Faults due to the human element usually take the form of "dry" joints, which are easily visible to the naked eye, and so are easily traced or observed and rectified during assembly.

HIGH-RESISTANCE JOINTS

The type of defective joint known as a high-resistance joint is a much more insidious cause of trouble in electronic equipment, for two reasons. First, it is very often not visible to the eye, and, secondly, its occurrence is not entirely due to the human element. It can be caused by a faulty process, incorrect soldering material, or insufficient heat, and usually results in a condition whereby perfect amalgamation has not taken place between the applied solder, the wire connection, and the pretinned soldering tag or other wire.

A perfectly tinned surface, and any subsequent soldered joint, depends for its strength and quality upon the adhesion resulting from the intimate contact between the solder and the articles to be soldered. This action is usually called "wetting," and in order to take place properly must be assisted by the use of a flux, whose purpose is to lessen by chemical action the surface tension of the metals involved in the joint.

To give a simple illustration of "wetting" and its relation to a flux material, consider the action that takes place if two drops of water are placed upon a greasy surface, with a minimum of space between them. Due to the surface tension of the water and the space between the drops, these will not flow together until the surface tension is removed or reduced. In order to do this, the greasy material round the drops must be removed by a flux or solvent, which in this case would have to be of a soapy nature. As soon as the soap has reduced the surface tension of the water, the two drops will instantly join up, wetting the material on which they are placed.

In making a perfectly soldered joint, the above process must be brought about, with the only differences that the liquid in this instance is not water but molten solder, and that the flux required is resinous rather than soapy.

SOLDERING MATERIALS

In the above discussion of high-resistance joints, it was pointed out that faulty or incorrect soldering materials can often be the cause. What, then, are the desirable characteristics for both solder and flux for radio soldering?

FLUX

There are several functions that it is very desirable for a soldering flux to perform but which are not always achieved in practice.

First, and most important, the flux must be able to reduce the surface tension of molten solder, causing it to wet metals rapidly. Next, joints made with the flux must not corrode even after long exposure to any degree of humidity. The flux after use should solidify completely and be hard and non-sticky, so as not to accumulate dust and dirt round the joint.

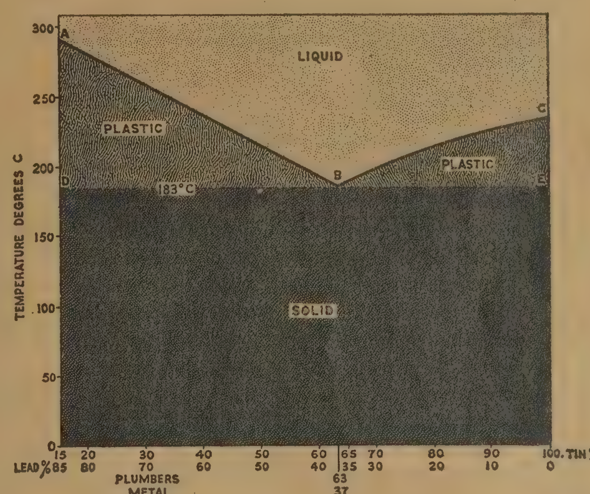


Diagram showing the behaviour of solders of various compositions on heating and cooling.

The flux should be capable of cleaning metallic surfaces by chemical action so that the solder can flow easily all over the joint area.

SOLDER

Solder is composed of tin and lead, combined as an alloy in a variety of proportions, according to the kind of soldering for which it is required. A major point which is not always understood is that for a given type of soldered joint there is an optimum solder composition. The diagram Fig. 1 helps to illustrate this. On the figure, the vertical scale represents degrees Centigrade, while the horizontal scale represents the composition of solder in terms of percentage of tin and lead. The line ABC shows the melting-point of solder of any composition. Thus, if an alloy of a given composition is raised to a temperature which is above the line ABC, at the point representing its composition, it is molten. The horizontal line DBE shows that below a temperature of 183 deg. C. all solders are solid. The area in between the lines ABC and DBE show regions of

composition and temperature in which neither complete liquefaction nor complete solidification has occurred; and the alloy is plastic and friable. To take an example, suppose we have a solder composed of 30 per cent. tin and 70 per cent. lead. From the point on the horizontal scale representing this composition, a vertical is erected. This vertical cuts the line AB at 260 deg. C., so that, as the solder is warmed up, it becomes plastic at a temperature of 183 deg. and remains plastic until the temperature rearches 260 deg., when it melts. On cooling, it becomes plastic at 260 deg. and remains so until it has cooled to 183 deg., when it solidifies.

It will be noted that as the composition is changed so as to contain a higher proportion of tin, the range of temperature over which plasticity occurs is reduced, until at a composition of 63 per cent. tin and 37 per cent. lead there is no plastic stage at all, the metal passing straight from the solid to the liquid state and vice versa.

This behaviour illustrates how different compositions have different setting periods—a fact which can be utilised when it comes to choosing a solder for a particular application.

TIME SAVED BY CORRECT ALLOY

For radio soldering there is a great advantage to be gained by using a solder rich in tin—for example, 65 per cent. tin to 35 per cent. lead. The advantage lies in the quick-setting properties of such an alloy. With it there is only a degree or two between the melting and solidification points, with the result that the joint takes very little time to cool to below 183 deg. C. and become completely solid.

When it is considered that a solder of the above composition can save from one to two seconds per joint, compared with a low tin-content alloy, the amount of time saved in a factory making millions of joints annually becomes very substantial.

BUYING SOLDER

Enough has been said to indicate that the manufacture of solder is not a thing to be undertaken lightly, nor is the choice of a solder for factory or even individual use. Some manufacturers of electronic equipment attach sufficient importance to the points raised in this article to consider analysis of batches of solder purchased as absolutely necessary to the efficient running of their assembly plant.

Even if analysis is not performed, or, rather, more especially so, it is of considerable importance to ensure that solder is purchased only from responsible manufacturers who make their product to given specifications and of highly-standardised quality.

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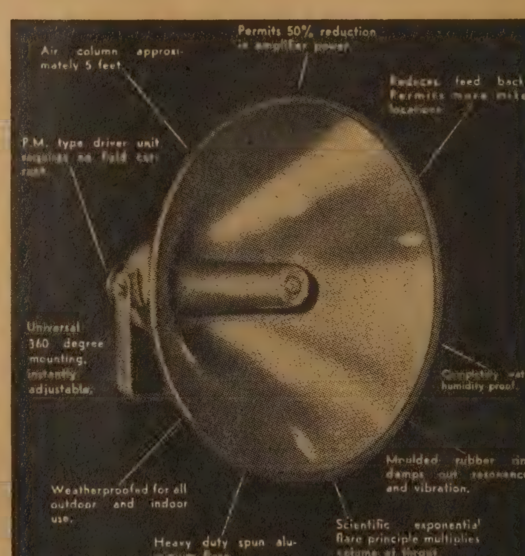

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A Practical Beginners' Course

PART 14

Having said something about the circuits used in our first experimental valve sets, and since they have now been built up and compared with the crystal set originals, it is time to say a little about how both crystal and diode detectors work. In this way we will obtain a more complete understanding of what we are about when we come to building one-valve sets, which are not just makeshift arrangements where the valve replaces the crystal detector.

HOW DOES A DETECTOR WORK?

In order to explain this, we will have first of all to say some more about the difference between alternating and direct currents. This question has been touched on before when we were endeavouring to see what a radio current is that is picked up by the aerial. So in the meantime we must put aside the question of how a detector operates until we have found out a little more about alternating current.

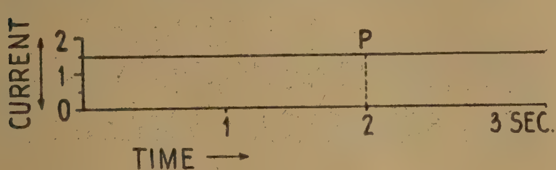


Fig. 23. This figure gives a pictorial representation of a direct current, and its behaviour with respect to time.

WHAT IS ALTERNATING CURRENT?

Alternating current is so called because it flows, not in one direction along a wire, but alternately backwards and forwards. Thus, a source of alternating current, such as the two terminals of an electric lamp socket, cannot be said to have one positive and one negative terminal, because each becomes positive or negative at the rate at which the reversals of current occur. The easiest way to describe this behaviour on the part of an alternating current source, such as an alternator (A.C. generator), is by means of a graph. No doubt many readers of this article

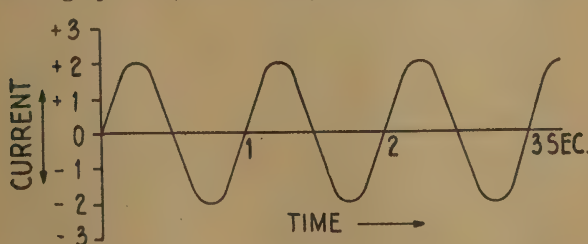


Fig. 24. Here is illustrated the behaviour of an alternating current with respect to time. Note that the value of current is changing constantly, and flows first in one direction and then in the other along the wire carrying it.

have had little to do with these useful devices, but a start must be made some time, and when the idea of a graph has been grasped, its extreme usefulness will be readily seen.

Figs. 23 and 24 are graphs showing respectively the behaviour of direct and alternating currents with regard to time. The introduction of the time factor into our thinking about electric currents is the only new idea presented, but is made quite clear by the figures. The horizontal and vertical lnies are called the **axes** of the graph in each case, and their intersection is called the **origin.** Along the vertical axis we represent current, and time is measured along the horizontal axis, the value at the origin in each case being zero. Between the axes we have a line representing in these cases how **current** changes as time goes on. The only thing which may cause difficulty to some is seeing how any particular time can be given for a value of 0 (nought). However, this is quite easy, for the time 0 (at the origin) simply represents the time at which we start measuring, and can be any particular moment we choose. The time axis is marked off in seconds. Thus, the time at the origin could be 12 noon or midnight, or breakfast time, or any time at all, but this is quite unimportant, because all that we are interested in is what happens 1, 2, 3, etc., seconds after any time we like to think of.

First, let us consider Fig. 23, which represents the behaviour of a direct current with respect to time. It will be noticed that the vertical axis has been marked off in amperes, the unit of current, just as the time axis has been marked off in seconds. The graph therefore represents a current of 1.5 amperes D.C. If we take, say, two seconds after the start of the measurement of current and erect a line perpendicular to the time axis, this cuts the graph at P. If now we proceed horizontally from P to the current axis, this will give us the value of current at the time of 2 seconds. In this case it is 1.5 amperes. If we do the same thing at, say, 3 seconds, graph tells us that at all times the value of current is the same, namely, 1.5 amps. This is a graphical we find the current is still 1.5 amps. Thus, the demonstration of what is meant by a direct current. A direct current of 1 amp. would be represented on the graph by a line parallel to the time axis, cutting the current axis at the 1-amp. mark.

Now, considering Fig. 24, one important difference can be seen. The current axis has been extended on both sides of the time axis, and we have introduced the term plus and minus to represent the top and bottom halves of the current axis. This procedure allows us to introduce on the graph the idea that current can flow in a wire in either of two directions. Suppose we have a wire laid parallel to the lines of this page. We could call a current flowing from left to right **positive,** and a current flowing from right to left would then have to be called **negative.**

The first thing which will be noticed about the graph of Fig. 24 is that part of the time the current is shown as above the time axis, and therefore as flowing from left to right in our imaginary wire, while the rest of the time it is flowing from right to left and is therefore shown below the time axis.

It can be seen, too, that at certain times the current is zero and that at all times the value of the current is changing. In Fig. 24, for instance, we have drawn a graph which represents a current that reaches a maximum value of 2 amperes in one direction, decreases, passes through zero, and builds up to a maximum value of 2 amperes in the opposite

direction. This is an exact description of just how an alternating current behaves.

Fig. 24 also explains the meaning of the term **frequency**, often found in dealing with alternating currents. At the starting time, marked zero, the current also is zero. A half-second afterwards the

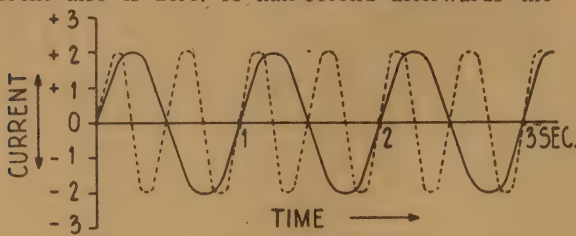


Fig. 25. Here we have two alternating currents, identical in all respects, except for frequency. The dotted one has twice the frequency of the solid one, since two complete cycles of the first take place during one cycle of the latter.

current passes through zero again, while one whole second after the start the current passes through zero a third time. Thus, between zero time and 1 second, the current has passed through its positive maximum, zero, and its negative maximum, and has reached zero again. If we now trace what happens between one and two seconds after the start we find that the whole process is repeated, and so on for as long as we like to continue the graph. The part between 0 and 1 second is called one **cycle**. Therefore, the part between 1 and 2 seconds is also one cycle. We can say, therefore, that the alternations take place at a rate of one cycle a second, or that the **frequency** of the current is one cycle a second. Fig. 25 shows two alternating currents drawn on the same graph. Each reaches the same maximum value of 2 amps. in each direction, but one goes through two complete cycles every second. Its frequency is therefore two cycles a second.

DIFFERENT FREQUENCIES

It will be remembered that in Part 3 of this series we mentioned that radio frequency currents picked up by the aerial were simply alternating currents of very high frequency, i.e., in which the alternations take place at some hundreds of thousands of times each second. Another alternating current, upon which we depend for our heat and light (when power cuts are not in force) is that supplied to us in our homes by the electricity supply authorities. The electric mains supply alternates only fifty times a second, which is a much smaller figure than we find for radio currents, which alternate at any frequency between 100,000 cycles a second and 3,000,000,000 times a second. Now, the way in which currents of such exceedingly high frequencies behave is very different from the behaviour of currents of lower frequency, but the fact remains that the only real difference between such currents is their frequency. This fact makes radio simply a branch of electrical engineering, because the laws which govern the behaviour of low-frequency currents are exactly the same as those which govern the performance of high-frequency ones. It is only the different ways in which various frequencies have to be controlled which makes radio appear to be a different subject altogether from the study of electrical engineering. In other words, electrical engineers are used to dealing with currents between 25 and about 500 cycles a second, while the radio engineer has to deal with currents between the limits roughly set down above. However, although radio frequencies are not called by that name if their frequency is less than about 100,000 cycles a second, radio men and telephone engineers are very much concerned with currents of frequencies between about 15 and 15,000 cycles a second. These are called **audio frequencies.** Roughly speaking, this term means "frequencies that can be heard." We have said "roughly," of course, because electric currents, of whatever frequency, cannot be heard at all. They flow quite noiselessly along the wires which carry them. What the term really means is that, if by some means, currents of these frequencies are made to produce mechanical vibrations of the same frequency, we hear a sound. This is because all sounds are caused by the mechanical vibration of something—as every schoolboy knows who flicks a rubber band to hear the "ping," or who sticks a broken nib in the desk and flicks it, producing a similar note. In other words, anything which is made to vibrate at any frequency within the range 15 to 15,000 times a second produces a sound we can hear.

What difference, then, does the frequency of the vibrations make to the sound? This is very simple, the rule being **"the higher the frequency of vibration, the higher is the pitch of the note we hear."**

Any vibration below about 15 times a second becomes a mere rumble, and not a note at all, while a vibration faster than about 15,000 times a second becomes so high in pitch that we cannot hear it at all. This does not prevent some animals from hearing such sounds, however, as is shown by the fact that some police forces have whistles with which to call their police dogs. These whistles produce a note so high in pitch that people cannot hear it, but the dogs can, because their hearing extends to higher frequencies.

MICROPHONES AND SPEAKERS

Now an alternating current, as our graphs showed, can be regarded as an electrical vibration, and all systems of producing sound waves electrically depend in the first place upon having an apparatus that will transform sound vibrations into electrical vibrations. Such an apparatus is a **microphone,** of whatever type it may be. Its job is what we have just stated, and this is exactly how it functions. It produces electric currents—alternating ones—which correspond exactly in frequency to the sound vibrations. Just how microphones do this we will have to leave for a later date, but the important thing to notice is that electric currents of frequencies corresponding to the sound vibration frequencies that we can hear are called **audio frequencies.**

At the other end of a sound-reproducing system we have either headphones or a loudspeaker, whose purpose is exactly the reverse of the microphone's. It is to convert alternating currents of audio frequencies into mechanical vibrations, which cause sound that can be heard.

From the above, we can see that alternating currents within the audio frequency range are most important, both for transmitting speech or music over wires—**telephony**—or through space without wires—**wireless telephony** or **radio telephony,** which are two names for the same thing.

MODULATION

The foregoing description brings us to another important new term, **modulation.** From what has

already been said, it can be seen that in some way or other the radio wave sent out by a transmitter for transmitting speech (or music) by radio telephony corresponds to the wires used to carry the audio frequency currents in ordinary or wired telephony.

In ordinary telephone work, the audio frequency currents produced by the microphone are conducted along wires to the telephone receiver just as wires carry the current from a battery or generator. The success of an ordinary telephone arrangement depends entirely on having a microphone and a receiver or loudspeaker which transform sound vibrations into alternating currents and vice versa.

On the other hand, the success of a radio telephone system depends not only on the microphone and loudspeaker, but on having some means of making a radio wave carry the audio frequency currents from one place to another. This means is known as **modulation.** In addition, because the radio wave sent out by the transmitter is made to carry the audio currents instead of a pair of wires, the radio wave is called the **carrier.**

THE DIFFERENCE BETWEEN MORSE AND TELEPHONE TRANSMISSION BY RADIO

In the transmission of morse by radio, the transmitter sends out its radio frequency wave, which is broken up into dots and dashes simply by turning the transmitter on and off. When the morse key is pressed, the transmitter comes on and stays on until the pressure on the key is lifted, when it goes off. Thus dots and dashes are made by turning the transmitter on for short and long periods. In between the dots and dashes, the transmitter is sending nothing at all.

This process is the simplest form of **modulation** of the radio frequency wave, which is simply chopped up into dots and dashes by the key. It can be regarded as modulation, because the **amplitude** or **size** of the radio currents emitted is varied by the key. The variation in amplitude in this case is from maximum (or full on) to minimum, which is no output at all.

In transmitting audio frequencies by radio, the transmitter is modulated by the audio frequency currents in much the same way as by the key in morse transmission. The main difference is that in phone transmission the radio frequency currents from the transmitter are varied gradually and not in jumps. Suppose we are transmitting a single note, for the sake of simplicity. This note will consist of an audio frequency current such as is illustrated in Fig. 24, only with a higher frequency, of course. What happens when the radio frequency output of the transmitter is modulated is that when the audio frequency current is at its maximum value in one direction, the transmitter output is maximum. When the audio current is at its maximum value in the opposite direction, the transmitter output is zero. Similarly, at the points on the audio frequency cycle where the

(Continued on page 48.)

Take the 'BUGS' out of Radio Construction with ARNRITE Coils Dials and Polar Gangs

R.F. AND I.F. COILS

The range of Arnrite R.F. and I.F. coils is sufficient to cover all the demands of radio construction. Aerial, R.F. and oscillator air-core coils are available unshielded or shielded, similarly the dual-wave coils are obtainable in these types.

Triple-wave coils, in which the broadcast, intermediate and short-wave coils are assembled in one $3\frac{1}{8}$ in. by $1\frac{5}{8}$ in. can are available in aerial, oscillator and R.F. sections. Shielded broadcast coils permeability tuned are also illustrated.

I.F. transformers, Litz-wound and mounted in $1\frac{5}{8}$ in. by $3\frac{1}{8}$ in. cans are manufactured in the following sizes: 465 k/c. iron core, 465 k/c. air core, and 175 k/c. air core.

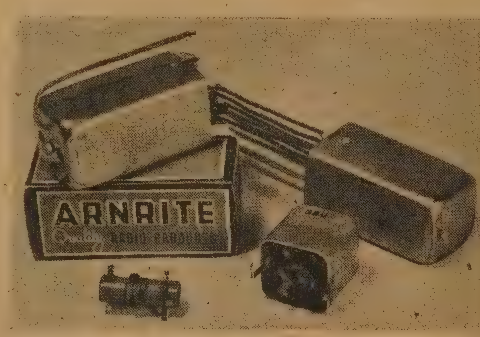
COIL ASSEMBLIES

Arnrite coil assemblies are available in a comprehensive range. The assemblies are completely wired and it is merely a matter of making the tube and voltage connections, thus eliminating the complex wave-change switch wiring. The assemblies include the coils, switch, trimmers, padders and by-pass condensers.

The Arnrite assemblies are available in Dual Wave (aerial and oscillator sections), Dual Wave (aerial, R.F. and oscillator sections), and Triple Wave (aerial, R.F. and oscillator sections).

Band coverage:

Broadcast	......	540	to	1800 k/c.
Intermediate	......	1.8	to	6.0 m/c.
Short-wave	......	6.0	to	20.0 m/c.



DIALS

Dials, accurately calibrated to function with Arnrite coils and "Polar" gangs, are mechanically rugged and are of the slide rule type with edge lighting. The following types are obtainable: Broadcast, Dual Wave, and Triple Wave.

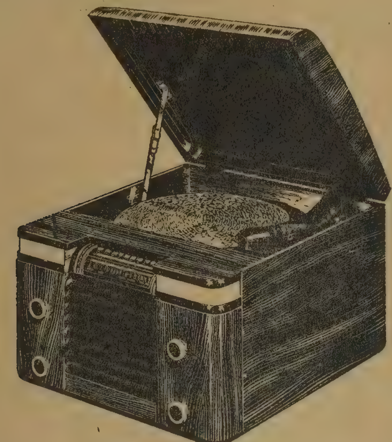
OBTAINABLE FROM ALL RADIO DEALERS

Wholesale Distributors: ARNOLD AND WRIG HT LTD., Auckland, Wellington, Christchurch

NEW PRODUCTS: LATEST RELEASES IN ELECTRONIC EQUIPMENT

THE PHILIPS MODEL 599 RADIOGRAM

Combining modern style with fine performance, the Philips 599 is the radio for those requiring a radio gramophone with the simplicity and compactness of a table model.



The 599 is a 5-valve dual-wave receiver conforming to Philips high standard of quality. Not only is it a splendid performer, but it is also a surprise packet tonally. It brings to the medium price field features usually associated with high priced instruments.

Specifications:

5-valve A.C. operated dual wave.
Valves: EBC33, ECH35, EF39, 6V6GT, 6X5GT.
Voltage: 230 volts, 50 cycles.
Mains consumption: 35 watts.
Frequency coverage: 540 kc/sec. to 1800 kc/sec. broadcast band; 5.8 mc/sec. to 19.2 mc/sec. short-wave band.
Speaker: Philips high quality "Ticonal" permanent Magnet. Provision for extra speaker.
Circuit: Superheterodyne, with A.V.C. Local and distance broadcast positions on wave-change switch.
Controls:
 Combined Off-On/Tone Control switch.
 Manual Volume Control.
 Tuning.
 Wave-change switch.
 R./Gram. switch.
Weight: Nett 31 lb.
Dimensions: Width 16 inches, height 12 inches, depth 18½ inches.

* * *

UNIVERSAL REPLACEMENT Q COILS

Types 40, 45 and 41 represent a new series of adjustable iron-core aerial, R.F. and oscillator universal replacement coils, adjustable in inductance to match any gang capacity from 360 mmfd. to 480 mmfd. maximum.

Coils type 40 and 45 (aerial and R.F.) are designed to maintain an even overall characteristic throughout their adjustable range of secondary inductance, and provide at all settings a superior selectivity curve and an increase in gain of approximately 2 to 6 db., compared with an average air-core coil of similar physical dimensions. When used in multi-band receivers with average switch capacity, gain throughout the broadcast band is substantially constant. In straight broadcast receivers, a variation in gain not exceeding 2.5 db. may occur. This can be reduced to zero by the addition of a small amount of plate to grid capacity.

The type 41 oscillator coil is adjustable for any I.F. frequency from 175 kc/sec. to 465 kc/sec. with gang capacities as stated in the first paragraph. By arrangement of circuit constants, the type 41 is suitable for use with practically any type of oscillator or converter valve. Oscillator grid current should be checked after installation to ensure that it is within the recommended values. For converter valves, such as 2A7, 6A7, 6A8, etc., normal oscillator voltage should be employed.

For 6K8 converter valves and valves of similar characteristics, oscillator anode volts should be reduced (to probably 50 to 75 volts) to give recommended grid current.

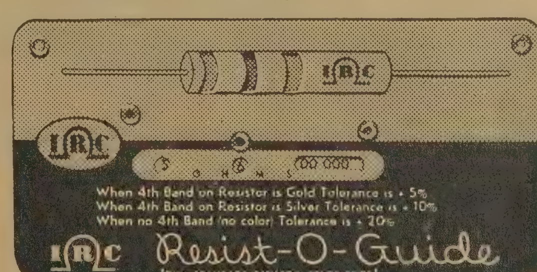
Coils are fitted with single hole mounting holddowns.

Overall dimensions (excluding threaded brass insert) are 1½ in. x ⅝ in.

These inductors will be available at the end of September from the manufacturers of Q coils, Messrs. Inductance Specialists, Wellington, or from their stockists throughout New Zealand.

* * *

RESIST-O-GUIDE COLOUR CHART



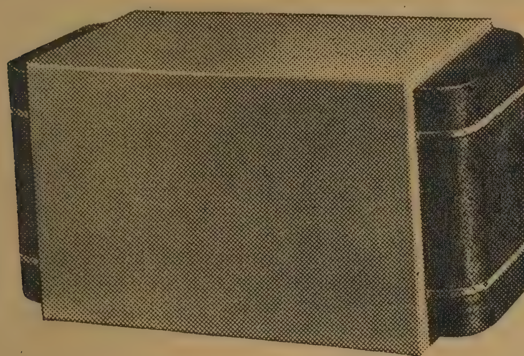
This handy colour chart makes the reading of resistors easy. The operation is simple, although not visible on the card, as illustrated, three small discs fit into a slot on the top of the card. These can be manipulated till colour appears in aperature and the resistance in ohms can be read on the scale. The chart is strongly made and has an attractive and practical varnish finish. The size, 4¼ x 2¼, fits neatly into a waistcoat pocket. Price, 1/- from S.O.S. Radio Ltd., 283 Queen Street, Auckland.

* * *

NEW TYPE AMPLIFIER CABINET

This handsome job is finished in grey and black crackle. Chrome plated bands complete the rounded ends. Chrome handles can be fitted on to the top for easy lifting. This amplifier is ideal for mounting two

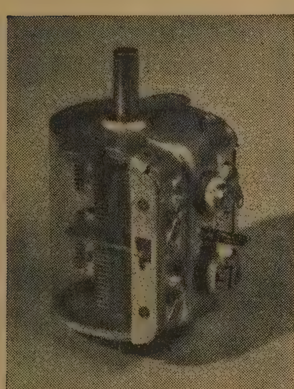
or more cabinets one on top of the other. The chassis is cadmium plated and punched with six valve holes and a power transformer hole. A small panel measuring 3 in. x 8¼ in. is placed on the top and front of the



chassis for mounting controls. The back is louvered for air circulation. Ideal for amplifiers, small receivers, modulators, etc. Sizes: Cabinet, 17½in. x 9in. x 9in. Chassis, 13¼in. x 8¾in. x 2½in. Price, £3 from S.O.S. Radio Ltd., 283 Queen Street Auckland.

* * *

A NEW PLESSEY GANG



For portable or midget receivers this Plessey 2-gang condenser cannot be surpassed. It is totally enclosed in a celluloid dust cover and has the trimmers mounted as an integral part of the condenser assembly.

Supplies are available from the Grover Electrical Co., Ltd., 11 Herbert St., Wellington.

THE "MODELMARK"

A very useful device for use in the radio and electrical industry, or, in fact, in almost any type of industry, is the "Modelmark" hard surface marking fount.

This 120-piece magazine fount as illustrated provides all the convenience and facilities of the rubber stamp, but possesses a performance and neatness obtained only by a die-stamping process.

The "Modelmark" embraces a full set of alphabetical and numerical characters of precision finish and dimensions. Hand magazine holders are included for single line sets from 9 to 29 characters, depending on size.

The "Modelmark" is suitable for indelibly marking a diverse range of materials in any form or thickness.

Typical examples of interest to all those requiring means of identifying their products are all metals, plastics, leather, wood, hard-rubber.

Stocks are available in sets of 1/6 in., 3/32 in., ⅛ in., and 3/16 in. from the New Zealand agents, Electronic and General Industries Ltd., 100 Dixon Street (P.O. Box 53, Te Aro), Wellington.

AVO OSCILLATOR

Radio servicemen will welcome the recent arrival of new "Avo" testing instruments.

The National Electrical and Engineering Co., Ltd. (NEECO), 286-288 Wakefield Street, Wellington, has just received a small consignment of the well known All-Wave Mains operated "Avo" Oscillator, an inexpensive, accurately modulated instrument ideal for test room and general laboratory use.

It covers a continuous fundamental frequency band from 95 Kc. to 40 Mc. by means of six separate coils mounted on a rotary turret selector. A harmonic calibration extends the range to 80 Mc. The large, clearly marked dial is directly calibrated throughout, accuracy being within 1 per cent.

Among an extensive selection of Avo testing instruments available, the Model 7 "AvoMeter" is a 50-range Multimeter giving readings of A.C. and possibly the most widely used in this country. It is D.C. Current, A.C. and D.C. Voltage, plus Resistance, Capacity, Power Output and Decibels.

Absolutely self contained, it is very simple to operate and almost impossible to damage electrically. The overall size is 7½ in. x 6½ in. x 4½ in., and nett weight six pounds.

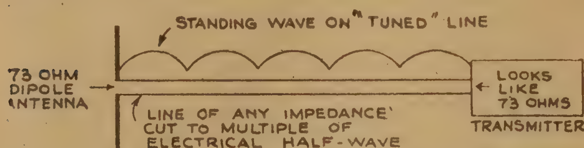
A PRACTICAL ANALYSIS OF ULTRA HIGH FREQUENCY TRANSMISSION LINES, RESONANT SECTIONS, RESONANT CAVITIES AND WAVE GUIDES

By J. R. MEAGHER and H. J. MARKLEY, R.C.A. Service Company Inc.

PART III

A line that is any multiple of one-half wave has the same characteristics.

The action of a half-wave section, or a line cut to a multiple of a half-wave, is used extensively in practical applications. For example, if a dipole antenna with an impedance of 73 ohms is to be coupled to the output of a transmitter, through an open-wire line (spaced pair) with a characteristic impedance of several hundred ohms, the line can be cut to a multiple of an electrical half-wave.



The transmitter will look into a load of 73 ohms, regardless of the impedance of the line.

"TUNING OUT" THE REACTANCE OF A LOAD

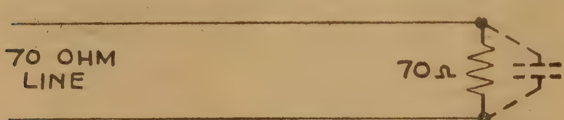
One of the important applications of tuned-line sections is to "tune out" the effects of residual capacitive or inductive reactance in a load, so the load will look like a pure resistance.

For example, assume that a 70-ohm resistor is used to terminate a 70-ohm line. If this line, with its resistor termination, is connected to a slotted line and checked for match over a wide range of frequencies, it will be found that at some frequency the termination looks resistive. This is the resonant frequency of the resistor. Above and below this frequency the resistor has capacitive or inductive reactance and no longer matches the line. In other words, the resistor is not a "pure resistance" at most frequencies.

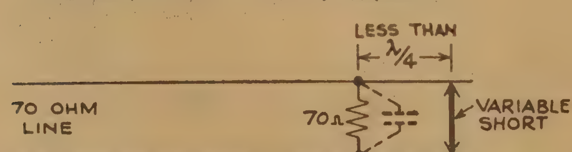
At the required operating frequency, the resistor may look like a resistance with shunt capacity, as shown in "A." If an inductive section of line is connected to the termination as shown in "B," it may be adjusted to resonate with the capacity, to look like a parallel-tuned circuit.

The line, therefore, instead of seeing a resistance with shunt capacity, now sees a resistance with a shunt parallel-tuned circuit, as shown in "C."

The parallel-tuned circuit looks like a high resistive impedance, as shown in "D," and therefore has little effect on the total resistance. If the combined resistance is correct, the line will be "matched."

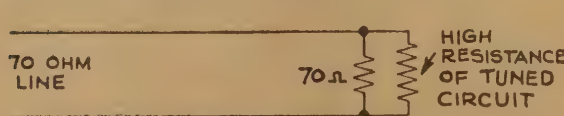


"A" - RESISTOR WITH RESIDUAL CAPACITIVE REACTANCE.



"B" - INDUCTIVE SECTION ADDED AND RESONATED WITH CAPACITY TO THE INPUT FREQUENCY.

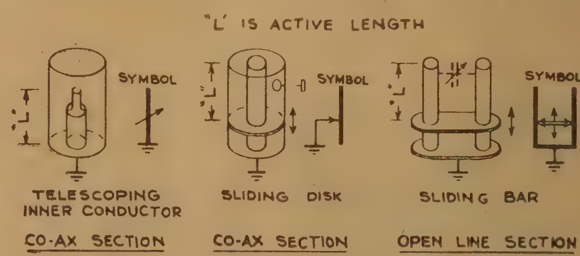
"C" - EQUIVALENT CIRCUIT OF "B"



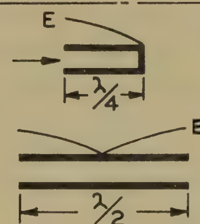
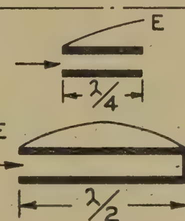
"D" - LINE NOW LOOKS INTO 70 OHM SHUNTED BY HIGH RESISTANCE.

TUNED LINE SECTIONS—TYPES OF CONSTRUCTION

The characteristics of tuned lines are used to good advantage in UHF equipments. Quarter-wave and half-wave sections are used as parallel- and series-tuned circuits, as step-up and step-down transformers, as impedance and phase inverters, and even as insulators. Such sections of line take the place of conventional tuned circuits which become too small and inefficient at ultra-high frequencies. The tuned-line sections are made in both co-axial form, and in open-line type, from metal tubes and rods; generally silver-plated to reduce R.F. losses. Some representative types of construction are sketched above. Methods of adjustment to resonate the sections are indicated.



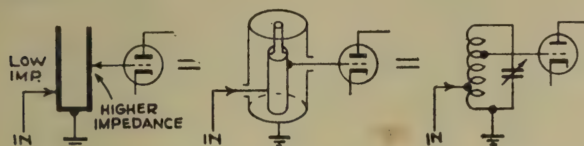
Some sections are cut short, and resonated with an adjustable capacitor (indicated by dotted lines) instead of being resonated with a sliding disc or bar.

WHEN INPUT FREQUENCY IS CONSTANT, AND THE CIRCUIT IS ADJUSTED				WHEN THE CIRCUIT IS CONSTANT, AND THE INPUT FREQUENCY IS ADJUSTED.	
ABOVE RESONANCE (SECTION MADE SHORTER) LOOKS LIKE	BELOW RESONANCE (SECTION MADE LONGER) LOOKS LIKE	CONVENTIONAL CURCUIT	RESONANT SECTION	ABOVE RESONANCE LOOKS LIKE	BELOW RESONANCE LOOKS LIKE
INDUCTANCE $(X_C > X_L)$	CAPACITY $(X_L > X_C)$	 AT RESONANCE THESE CIRCUITS LOOK LIKE A HIGH RESISTIVE IMPEDANCE, OR "OPEN CIRCUIT"		CAPACITY $(X_L > X_C)$	INDUCTANCE $(X_C > X_L)$
CAPACITY $(X_C > X_L)$	INDUCTANCE $(X_L > X_C)$	 AT RESONANCE THESE CIRCUITS LOOK LIKE A LOW RESISTIVE IMPEDANCE, OR "SHORT CIRCUIT"		INDUCTANCE $(X_L > X_C)$	CAPACITY $(X_C > X_L)$

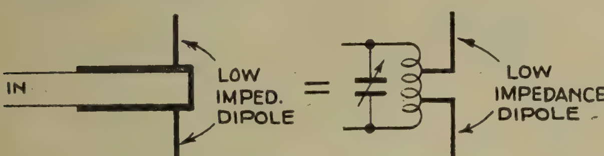
TUNED LINE CHARACTERISTICS REPEAT WHEN MULTIPLES OF AN ELECTRICAL HALF WAVE ARE ADDED

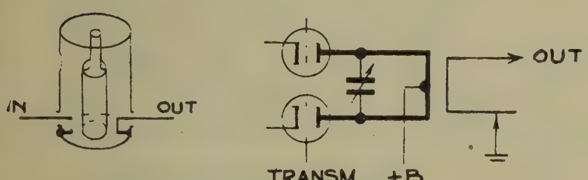
QUARTER-WAVE SECTIONS AS TRANSFORMERS

A quarter-wave section (co-ax or "open-line" type) shorted at the end may be used as a step-up transformer, similar to a parallel-tuned auto-transformer. When a resonant section is "loaded" with reactance, for example, connected to the grid of a tube, the section must be readjusted to obtain electrical resonance.



A quarter-wave shorted section may be used as a step-down transformer.





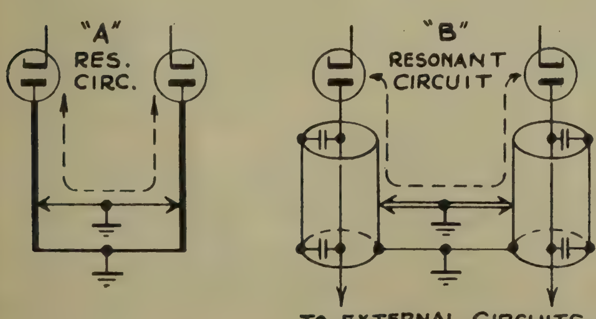
CO-AX ARMS ON TUNED SECTIONS

In push-pull UHF circuits, lengths of co-ax are frequently used to form the arms of one-quarter or one-half wave shorted sections. This is done for several reasons, including:

(1) The inner conductors may be used to carry D.C. and A.C. supply voltages, or low-frequency signals, to the tube elements.
(2) The outer conductors can be grounded.
(3) A sliding bar on the outer conductors can be used to adjust the electrical lengths of the section mentioned in (1) above.

In such applications, capacitors are used at the end of the co-ax to place the inner and outer conductors at the same R.F. voltage.

An example of co-ax arms forming tuned sections is shown in the illustration.



"A" is the quarter-wave shorted section required for input tuning. But it is necessary to take the diode currents to external circuits, and (for constructional reasons) the arms of the section must be grounded. "B" shows how "A" is rearranged to do this. **The co-ax lines do not act as tuned sections by themselves, but form the arms of the quarter-wave shorted sections shown in "A."**

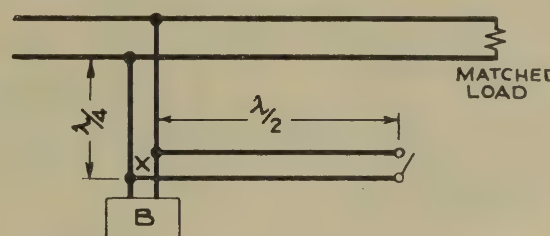
MISCELLANEOUS APPLICATION OF TUNED SECTIONS

Tuned sections are put to many uses in addition to that of replacing conventional tuned circuits.

Some miscellaneous uses are described to indicate several of the many applications.

(1) Use of Sections in Switching Circuits

In some equipments, it is necessary at times to prevent signals from "A" getting to "B." This is acomplished by shorting the end of the one-half wave

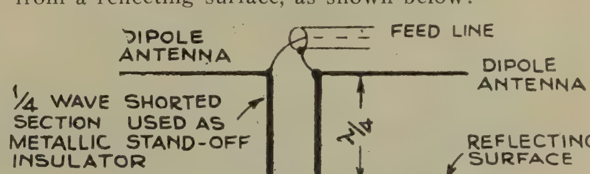


section. By virtue of the action of one-half wave sections, this short appears as a short across "B" input line at "X." The one-quarter wave line, being thus shorted at "X," looks like a high impedance to the signal from "A."

When it is desired to leave signals through to "B," the switch is opened at the end of the one-half wave line. At "X," the one-half wave resonant line now looks like an open circuit. With no short at "X," the one-quarter wave section is simply an ordinary part of the line, and signals can pass to "B."

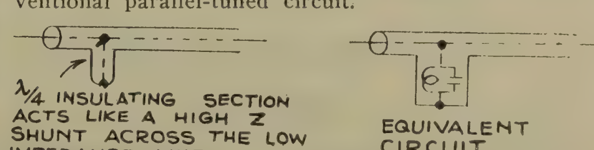
(2) Quarter-wave Shorted Section Used as an Insulator

(a) A quarter-wave shorted section looks like a high resistive impedance. This fact is utilised in some antenna systems by employing one-quarter wave shorted sections as metallic stand-off insulators to support and space a dipole antenna one-quarter wave from a reflecting surface, as shown below:



The quarter-wave section looks like a high impedance to the antenna feed line. (The feed line can be run inside one arm of the quarter-wave section.)

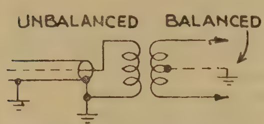
(b) Another example of a quarter-wave "insulator" is shown below, together with an analogy of a conventional parallel-tuned circuit.



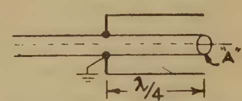
(3) Line Balance Converter (Bazooka)

In some applications, it is necessary to change from a co-axial transmission line (unbalanced, since outer conductor is grounded) to a balanced transmission line or load (both conductors approximately the same impedance above ground).

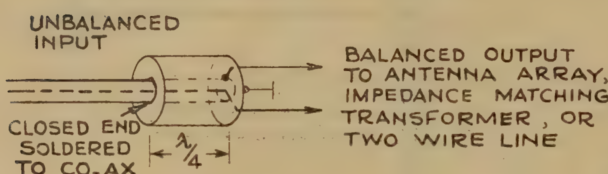
A "bazooka" is used for this purpose. The action is shown in the sketches, and may be explained as follows:—



PRINCIPLE OF CONVERTER



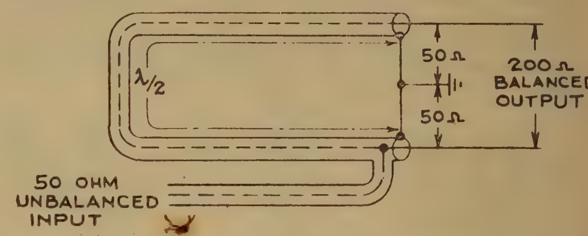
BAZOOKA FORMS SHORTED QUARTER WAVE SECTION PLACING "A" AT HIGH Z TO GROUND.

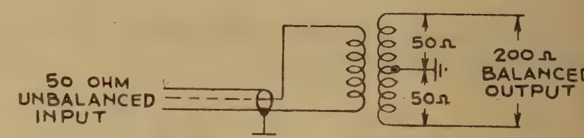


(1) The quarter-wave shorted section effectively removes the R.F. ground from the end of the outer conductor of the co-axial line.
(2) Both the inner and outer conductors of the co-axial line are at a relatively high impedance above ground, and effectively balanced to ground.
(3) The bazooka may be used in reverse manner to an unbalanced circuit.

(4) Half-wave Phase and Impedance Converter

The following arrangement is used in some applications. The action may be reversed, to feed high-impedance balance input to low-impedance unbalanced output.





(To be continued.)

RADEL QRP TRANSMITTER

(Continued from page 18.)

connection is made, it is possible to advance the gain control before overloading occurs in the modulated stage. This means a higher effective percentage modulation, with greater effective range on phone operation.

The question is, how can the correct microphone polarity be determined? If one has an oscilloscope, this is easy, for all that is necessary is to examine the speech waveform at the modulator plate. If the positive peaks are greater in amplitude than the negative ones, the phasing is correct. If not, the microphone leads should be reversed. With some types of microphone, which have a shielded output lead, one of which is used as one conductor for the microphone currents, it will be necessary to get inside the micprohone itself and change over the leads. If two leads are brought through the shield cable, it is only necessary to reverse these at the output end to correct the phasing, should this be necessary.

Of course, adding a further speech amplifier stage would reverse the polarity of the signal at the modulator, but this is hardly to be recommended as a method.

If an oscilloscope is not available, it should be possible to find out the right connection for the microphone by trial. The connection which allows the highest setting of the gain control before too much distortion sets in is the right one.

VOLTAGE READINGS

The following voltage readings taken with a 1000-ohm-per-volt meter may act as a guide to constructors.

(a) Phone

H.T. supply	260v.
Modulator amplifier plate	240v.
Modulator plate	260v.
Oscillator screen	100v.
Doubler screen	200v.
Final amplifier screen	180v.
V_4 plate	50v.
V_5 cathode	1v.
V_6 cathode	13v.

(b) C.W.

Final amplifier plate	260v.
Final amplifier screen	200v.

In addition, voltages on the oscillator and doubler will be slightly higher than on phone operation.

(c) Final Amplifier Plate Current

On both phone and C.W., the final should be loaded to 40 ma. This gives a D.C. power input to the final amplifier of 9.6 watts on phone and 10.4 watts on C.W.

This Month's "Inductances Q-QUIZ"

WHAT IS TOP-CAPACITY COUPLING?

Of recent years, high impedance primaries have become almost universal practice in the design of aerial and R.F. coupling transformers for broadcast and the lower short-wave frequencies.

This type of coupling avoids the main disadvantage of low-impedance primaries in that it enables the R.F. stage to be given almost constant gain over the whole tuning range of the coil. In fact it is possible to over-compensate for the normal drop in sensitivity at the low-frequency end of the dial.

In "Q" aerial and R.F. coils this over-compensation is purposely employed, since it gives a coil with a large overall gain, and what is known as top-capacity coupling is employed to level up the response over the band once more. This additional coupling is not made by an actual condenser connected from the primary to the grid end of the secondary, as the required capacity is quite small, but is achieved by relying on the inevitable stray capacities brought into being when the coils are wired to the wave-change switch.

INDUCTANCE SPECIALISTS

202 Thorndon Quay, Wellington.

QUESTIONS AND ANSWERS

(Continued from page 22.)

Note.—In the case of dual-purpose tubes, the appropriate letters are combined.

The Numbers:

A simple suffix number represents the stage of development of the tube. If this number is preceded by another number, it represents a physical difference between tubes of the same type. For instance EL3 is a particular output pentode with a side-contact base. The EL33 is the same tube with an octal base.

BEGINNERS' COURSE

(Continued from page 35.)

audio current is zero, the transmitter output current is half the maximum value. Now, this process is the same, whatever the frequency of the audio current, for the only difference that this makes is to change the number of times a second that the transmitter output is changed from maximum to zero. Thus, if the audio frequency is 100 cycles a second, the transmitter output is changed from maximum to zero 100 times every second. If, on the other hand, the audio frequency is 1000 cycles a second, the transmitter performs the same operation as before, but 1000 times every second.

(To be continued.)

GOSSIP COLUMN

(Continued from page 15.)

Maurie's chief relaxation is golf, and he is recognised as one of the toughest on his mark at Titirangi.

He is the eldest son of Geo. Bush, well known Boxing Judge and ex-President of the Northern Boxing Association. His younger brother is Ron Bush, ex-All Black.

*

Besides his association with Bobbie Pins Ltd., Maurie Bush is also acting manager of N.Z. Wires & Cables Ltd.

RECEIVER BIAS SUPPLIES

(Continued from page 27.)

Fig. 4

C	Load Resistor 25k.	50k.	1 meg.
0.035	30	50	125v.
0.041	40	60	130v.
0.05	45	75	140v.
0.062	60	100	180v.
0.083	90	160	310v.
0.12	140	280	500v.
0.25	270	400	500v.

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